Transition, School, Friends and Obesity Risk Models
(The TranSFORM Study)

by

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Submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

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TranSFORM

Transition, School, Friends & Obesity Risk Models
I am the author of the thesis entitled

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(The TRANSFORM Study)

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Undertaking my PhD has been a rewarding and challenging experience, taking me on a journey of learning and discovery. Whilst only my name is written on the title page, this thesis would not exist if it were not for the support from many people along the way.

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List of publications and conference presentations

This thesis is presented by publication in peer reviewed journals. At the time of thesis submission, three papers were published and one submitted as indicated. Presentations (oral and poster) arising from this thesis are also listed following the publication list.

Publications

Status: Published

Status: Published

Status: Published

Status: Submitted upon invitation to the ‘Special Issue on the Coevolution of Networks and Health’, after acceptance of abstract
**Conference abstracts and presentations**


Nichols M, **Marks J** 2015, ‘Social network analysis’, *National Health and Medical Research Council Centre of Research Excellence in Obesity Policy & Food Systems PhD Showcase*, Deakin University. [Oral presentation]

**Marks J**, de la Haye K, Barnett LM, Allender S 2015, ‘If your adolescent friends are physically active, are you?’, *Australia and New Zealand Obesity Society Annual Scientific meeting*, Melbourne. [Poster presentation]

Executive summary

Thesis structure
The structure of this thesis is in three parts. Part A provides background to the study through introduction, literature review and methods chapters. Part B presents thesis results by publication, and Part C draws the thesis together, comprising a discussion and final conclusion chapter.

Executive summary
Childhood obesity is a major health concern and multifaceted problem, requiring an understanding of influences on obesity risk behaviour for informing prevention efforts. The period from childhood to adolescence, a significant and influential life stage when peers become increasingly important referents for behaviour, is also a time when healthy weight behaviours are in decline. In many countries including Australia, this period coincides with a shift of school environment as pre-early adolescents’ transition from primary to secondary school, having the potential to impact on obesogenic (tendency to cause obesity) behaviours of low physical activity (PA), excessive sedentary behaviour, and energy-dense nutrient-poor diets. Yet there is a scarcity of evidence of the impact that a disruption of physical and social environment has on behaviour, which this thesis sought to address. Specifically, thesis aims were to: 1) explore the effect of a change of school environment on physical activity, sedentary and dietary behaviours as children transition from primary to secondary school; and, 2) examine social influences of friendship networks on these behaviours over this period.

Findings from this thesis are presented by publication comprising four manuscripts, which together address the major aims and research questions. Paper 1 examined the effect of the school transition on physical activity and sedentary behaviour using a longitudinal cohort study design (N=243) over two phases, the first phase when students were in primary school and the second phase when students were in secondary school. Sixty-three percent of students
changed their school environment when transitioning to secondary school, whilst 37% remained in the same combined primary-secondary school system across the transition period. A statistically significant difference was found between the student cohorts, with a greater reduction in PA intensity during school breaks, and an increase in recreational screen time for students who changed school. These results demonstrate that a disruptive shift in the school environment has a direct effect on PA and sedentary behaviour in early adolescence. School staff surveys identified school PA environment differences between primary and secondary schools that potentially contributed towards these variances.

Paper 2 further explored the effect of a change of school environment, with the same participants and longitudinal study design, but for dietary behaviour. A change of school was shown to have a statistically significant negative effect on sugar sweetened beverage intake, and increased frequency for purchasing snack foods after-school. Weight status was not associated with dietary behaviour. There were some notable differences between school food environments, with less secondary schools having healthy canteen/food service policies and more days of food service operation, than at primary schools. Overall, the school transition had an effect on a range of PA, sedentary and dietary behaviours, with some differences in school PA and food environments that may be implicated for some behaviour change between primary and secondary school.

Having determined that the school transition has an impact on obesogenic behaviour, and given that a change of school is associated with a disruption in social networks, the focus of papers 3 and 4 was to explore the effect of social networks on the behaviours of interest. Clear evidence was found in a cross-sectional study (N=310) of associations between various characteristics of student friendship networks and individuals engaging in PA (e.g., time/intensity) and sedentary behaviours in late primary school (paper 3). Therefore paper 4, a longitudinal study (N=308), further explored and identified several friendship network characteristics as predictors of change in a range of obesogenic
behaviours in late childhood and early adolescence. These results, generally differing by gender and some with opposing effects (e.g., an increase in the proportion of very active friends was predictive of a decrease in moderate-to-vigorous PA over time for males), demonstrate the contextual and dynamic complexity of social influence mechanisms on different behaviours.

As a whole, the studies presented in this thesis demonstrate that a disruption to the physical and social environment over the period from childhood to adolescence has a significant impact on healthy weight behaviour. Specifically, whilst the transition from primary to secondary school generally has a negative impact on obesogenic behaviour, numerous characteristics of students’ friendship networks were shown to have positive differential effects on a range of PA, sedentary and dietary behaviours both within and external to the school context.

As the first study to explore the impact of the school transition on multiple obesogenic behaviours, this research has added important knowledge to the field of childhood obesity prevention by providing evidence of mechanisms affecting behaviour change at a critical life stage. It is conceivable that a lack of understanding of the dynamics of friendship influence (e.g., where peer influence is strong for girls engaging in excessive screen time) could unhinge health behaviour intervention efforts that target changes to the physical environment only. The evidence clearly directs the importance for understanding contextual influences on obesogenic behaviour to help identify potential areas for effective behaviour change intervention. It is possible that harnessing these social mechanisms could be used to promote desired behaviour and reinforce healthy weight behaviour norms for the prevention of obesity and related health risks in adolescence and beyond.
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**Chapter 1: Introduction**

### 1.1 Background and context

Childhood obesity is a major health concern, highly prevalent, complex and associated with chronic disease risk (Wang & Lobstein 2006; World Health Organization 2009). Whilst interventions focus on modifiable risk behaviours of inadequate physical activity (PA), excessive sedentary time and poor diet, the complexity of the problem calls for further analytical methods and system-level evidence to understand how to target behaviour for future obesity prevention intervention efforts (Must, Barish & Bandini 2009; Waters et al. 2011).

Socioecological influences on behaviour are well recognised (Bronfenbrenner 1977; Swinburn, Egger & Raza 1999; World Health Organization 1986), and for school aged children, the school environment represents a major influence on behaviour and health and well-being (Viner et al. 2012). Whilst most school based evidence is within the primary or secondary school setting (Brown & Summerbell 2009), there is very little research of the impact that a change of school system has on obesogenic behaviour as children transition from a primary to secondary school environment, where the term obesogenic refers to behaviours and/or environments that contribute towards excessive weight gain (Egger & Swinburn 1997). The Australian school system, where students transition from year 6 primary school to year 7 secondary in one of two systems, namely: 1) from a discrete primary to a discrete secondary school, or 2) remain within the same combined primary-secondary school over this period; provides an ideal opportunity to study the impact that a disruptive shift of school environment may have on health behaviours.
Along with declining PA and excessive sedentary and low-nutrient energy-dense diets tracking through childhood (Borraccino et al. 2009; Craigie et al. 2011; Department of Health 2014a; Department of Health and Ageing 2007; Dumith et al. 2011; Leech, McNaughton & Timperio 2014; Nader et al. 2008; Sisson et al. 2009), it may also be expected that a disruptive change of school environment (physically and socially) over the period from late childhood to early adolescence has a further detrimental effect on these behaviours.

Despite recent emerging evidence of peer influence on these behaviours (Fletcher, Bonell & Sorhaindo 2011; Salvy et al. 2012; Sawka et al. 2013; Sawka et al. 2015), and recognising the increasing importance of friends from pre-early adolescence (Brown 2004), evidence of social mechanisms on behaviour change is scant. There has also been very little longitudinal research and exploration of the various social network characteristics that predict behaviour change over this period. Social network analysis, a method of describing relationships within complex systems, is an emerging field in public health, and appropriate for furthering this research (Luke & Stamatakis 2012; Mabry & Kaplan 2013).

In the absence of longitudinal evidence of peer influence on PA, sedentary and dietary behaviour over the primary to secondary school transition, the Transition, School, Friends and Obesity Risk Models (TranSFORM) study explores the effect of a change of school (physical and social) environment on obesogenic behaviour.

1.2 Study aims

The major aims of TranSFORM are to: (1) explore the effect of a change of school environment on obesity related behaviours of physical activity, sedentary and dietary behaviour, as children transition from primary to secondary school; and, (2) examine the influence of friendship networks on these behaviours over this period.
1.2.1 Research questions and hypotheses

This research comprises four major research questions which are listed below along with their corresponding hypothesis.

RQ1. Do obesogenic behaviours change as children transition from primary to secondary school?

Hypothesis: That obesogenic behaviour will increase over the transition from primary to secondary school, irrespective of whether this incorporates a change in physical school environment as students move from one school year-level to the next.

RQ2. Is there greater change of obesogenic behaviour for students who change their school environment?

Hypothesis: That students who change their physical school environment will have a greater change in PA, sedentary and dietary behaviour than students who do not change school over the transition from primary to secondary school.

RQ3. What are the differences between primary & secondary school contexts in relation to children’s PA & food environments?

Hypothesis: That differences in school PA and food environments between primary and secondary school can be identified that have the potential to influence children’s eating and PA behaviours.

RQ4. Are friendship networks associated with a change in obesogenic behaviour?

Hypothesis: That characteristics of personal networks in late childhood and early adolescence are predictive of PA, sedentary and dietary behaviours.
1.3 Study significance

Targeting PA and diet for the prevention of childhood obesity and longer term non-communicable disease is a global public health priority (World Health Organization 2014). Given the decline in PA and diet from childhood to adolescence and the many socioecological factors influencing these behaviours, it is important to identify potential areas where healthy weight behaviour can be improved. The transition from primary to secondary school, a significant life stage at a period when PA is in decline, is potentially one of these areas.

TranSFORM is the first longitudinal study to follow two cohorts of children from primary to secondary school (one cohort undergoing a change of school, and one cohort not undergoing a change of school) to examine the impact of a change of physical and social environment on PA, inactivity and dietary behaviour. This study further explores the impact that friends have on behaviour for an understanding of social influences and mechanisms that predict behaviour change over this period.

An understanding of these physical (school environment) and social influences on behaviour may be useful for policy makers to help inform school policy and design (e.g., PA environment and curriculum) that promotes continuity of healthy weight behaviour over the transition between school systems. Findings from TranSFORM may also provide valuable information for enhancing and informing areas of intervention to harness peer influence that promotes healthy weight behaviour in early adolescence.

1.4 Overview of study design

TranSFORM is the first prospective longitudinal cohort study to leverage different school types towards understanding the impact of the school transition on obesogenic behaviour. The study design follows children attending two different school systems over the transition from their final year of primary
school (year 6) to their first year of secondary school (year 7) (Figure 1). The exposure of interest is a change of school environment between primary and secondary school. The study cohort are students who transition from year 6 primary school to a discrete secondary school in year 7, whilst the comparison cohort are students who attend a combined primary-secondary school without undergoing a change of school as they progress from year 6 to year 7. Outcomes of interest are changes in weight status and dietary, PA and sedentary behaviours over this period.

**Figure 1 TranSFORM study design**
In October-December 2013, 310 students participated in TranSFORM, recruited from a random sample of 15 government primary schools within Victoria, Australia. In April-June 2014, 308 of these students also participated in phase 2 of the study. Student anthropometric, PA, sedentary behaviour, dietary behaviour and friendship data were collected at both time points. School staff at each school were invited to participate by completing a school environment (PA and food) and capacity (in relation to childhood obesity) questionnaire.

Mixed model regression analyses for longitudinal data were conducted to examine the differential effect on behaviour between changing or not changing schools. Descriptive analyses of school PA and food environments were conducted between school types. Regression models were used to examine relationships between personal network characteristics and obesogenic behaviours. Further details on the study design are provided within the Methods and relevant sections of each results paper.

1.4.1 Abbreviations and operational definitions

Repeated abbreviations and terms used within this document are as follows.

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMI</td>
<td>Body mass index</td>
</tr>
<tr>
<td>BMIz</td>
<td>BMI childhood standardised score (by age and sex)</td>
</tr>
<tr>
<td>Childhood</td>
<td>Children and adolescents of school age</td>
</tr>
<tr>
<td>MVPA</td>
<td>Moderate to vigorous physical activity</td>
</tr>
<tr>
<td>Obesogenic</td>
<td>Obesity promoting (behaviour or environment)</td>
</tr>
<tr>
<td>PA</td>
<td>Physical activity</td>
</tr>
<tr>
<td>P-12</td>
<td>Combined primary-secondary (years Preparatory-12) school</td>
</tr>
<tr>
<td>RQ</td>
<td>Research question</td>
</tr>
<tr>
<td>Sedentary</td>
<td>Low energy waking behaviour (e.g., sitting, lying down)</td>
</tr>
<tr>
<td>SEIFA</td>
<td>Socio-Economic Indexes For Areas</td>
</tr>
<tr>
<td>SNA</td>
<td>Social network analysis</td>
</tr>
<tr>
<td>Transition (school)</td>
<td>The transition from primary to secondary school</td>
</tr>
<tr>
<td>Transition (life stage)</td>
<td>The period from childhood to adolescence</td>
</tr>
</tbody>
</table>
1.5 Ethics

Ethics clearance was obtained from Deakin University (DUHREC 2013-093) on 16th May 2013 and permission to approach Victorian government schools was received from the Department of Education and Early Childhood Development (2013-001992) on 26th June 2013. Permission to approach catholic schools was received from the Archdiocese of Melbourne on 18th June 2013, the Diocese of Ballarat on 17th June 2013, the Diocese of Sale on 5th July 2013, and the Sandhurst Catholic Education Office on 27th June 2013 (Appendix A). Please note documentation refers to the original name of the study, namely ‘Friends and health behaviour over the primary to secondary school transition’.

This study complies with the Victorian Information Privacy Act 2000 and Commonwealth Privacy Act 1988 for the protection of recorded personal information of study participants. Information collected within this study is in re-identifiable and non-identifiable form. The nature of social network methodology requires the names of students to be collected for friendship identification. Names are collected for no other purpose, are coded for analysis and will be stored in non-identifiable form at the completion of the project. Information resulting from this research is published within peer reviewed journals or owned by Deakin University, where only research personnel have data access. All paper data (e.g., consent forms, questionnaires) are stored in locked filing cabinets at Deakin University, archived at the completion of the project and will be destroyed after seven years. Electronic data is stored on a Deakin University server with restricted access.
Chapter 2: Literature review

This literature review\(^1\) comprises three parts.

The first section presents the current problem of childhood obesity in relation to prevalence and health risks. Evidence of modifiable obesogenic behaviours of inadequate physical activity (PA), excessive sedentary time, and poor diet are outlined, identifying the need to improve these behaviours for chronic disease prevention.

Using an ecological systems perspective, the second section presents the transitional life stage from childhood to adolescence as an influential period for health behaviour change. Over this period, the transition from primary to secondary school represents a major shift of physical and social environments, having the potential to impact upon obesity risk behaviour.

The third section introduces theories of social influence, and the importance of peer influence on behaviour in adolescence. Social network analysis methods and theories are then presented, as an appropriate tool for analysing peer influence on obesity risk behaviour. Current evidence of social network influence on these obesogenic behaviours in adolescence is then outlined.

Finally, the gaps in existing research and knowledge are presented, along with a case for further research that is addressed through the studies within this thesis.

Figure 2 provides a diagrammatical overview of the literature review structure.

\(^1\) As a literature review of multiple topics as outlined within Figure 2, searches were conducted using search terms as appropriate. Searches were not restricted to particular databases or period, with the most recent evidence included within each relevant section of the literature review. Literature searches utilised comprehensive library databases available through the university library, (e.g. including host databases such as EBSCO Host, providing access to databases such as Academic Search Complete, Business Source Complete, Global Health, Medline, PsycARTICLES, SocIndex, etc.), and grey literature (e.g. government reports).
Figure 2 Literature review overview

- **Section 1: Childhood Obesity**
  - Childhood obesity: prevalence & health risks
  - Tracking of risk behaviours through childhood: physical activity, sedentary behaviour, eating behaviour

- **Section 2: Transition years**
  - Childhood to adolescence: an influential life stage
  - Ecological systems perspective: environmental and social influences on individual behaviour
  - Change of environment: primary to secondary school

- **Section 3: Social influence & networks**
  - Social influence theory
  - Social network analysis and theory
  - Social networks, obesity and risk behaviour

- **Evidence gap**
  - Impact of a shift of school physical and social environments from late childhood to early adolescence on obesity risk behaviour
2.1 Childhood obesity, health and risk behaviour

2.1.1 Obesity prevalence and health

Obesity, declared a worldwide epidemic, is highly prevalent and associated with health risks both in the short and long term (Wang & Lobstein 2006; World Health Organization 2009). As a major contributor to the global burden of disease and disability, obesity, defined as excess adiposity, is causally affiliated with preventable chronic diseases inclusive of diabetes, cardiovascular disease, stroke, hypertension and some cancers, and an estimated annual mortality rate of 2.8 million adults (World Health Organization 2015b). Obesity prevalence has more than doubled since 1980, with over 1.9 billion adults overweight or obese in 2014, representing more than 13% of the global population (World Health Organization 2015b).

With unacceptably high prevalence rates, overweight and obesity in childhood represents a global public health crisis (Ogden et al. 2012; World Health Organization 2015a). In children, overweight and obesity is measured in terms of body mass index (BMI), a ratio of weight to height that is correlated with excess adiposity (body fat), or waist circumference as a measure of central adiposity (World Health Organization 2015a). BMI for children up to age 18 is calculated by sex and age percentile (due to differences in body fat in childhood and adolescence) to give relative weight-for-age rankings (Cole & Lobstein 2012). Overweight is defined as between the 85th and 95th percentile, and obesity over the 95th percentile. Global obesity prevalence is unavailable for children over 5 years, however national data shows prevalence is high. There are parallel trends in the United States (U.S.) (Ogden et al. 2014), United Kingdom (U.K.) (Department of Health 2014a), and Australia (Australian Bureau of Statistics 2009b), where approximately one quarter to one third of children and adolescents were overweight/obese based on 2007-2013 data. Prevalence has also been shown to increase with age, for example within Australia, 25% of
children aged 5-17 were defined as overweight or obese in 2007/8, increasing from 22% in childhood (age 5-12) to 29% in adolescence (age 13-17) varying slightly by gender (Figure 3) (Australian Bureau of Statistics 2009b). Previous data show rates to increase over time as well as by age. For example, in 1995 21% of Australian children aged 5-17 years were overweight or obese, increasing to 43% when this age cohort was 18-30 years in 2007-8 (Australian Bureau of Statistics 2009a). Recent evidence suggests that rates may be plateauing or in decline (Olds et al. 2010), although severe obesity continues to trend upwards (Skinner & Skelton 2014).

Overweight and obesity in childhood has lasting consequences. Excess weight (assessed via BMI measures) has been shown to track from infancy to early childhood (Baird et al. 2005; Gardner et al. 2009), pre-adolescence to adolescence (Garnett et al. 2005; Magarey et al. 2003; Williams et al. 2011), and from several development stages in childhood (early childhood to adolescence)
to early adulthood (Deshmukh-Taskar et al. 2006). Investment in early prevention and treatment is therefore critical to alter these trajectories.

Health issues associated with obesity in childhood and adolescence

Overweight and obesity is associated with psychological, health and social problems throughout childhood and adolescence. Excess weight in childhood significantly increases the risk of premature morbidity and mortality in adulthood, being associated with diabetes, hypertension, ischaemic heart disease, stroke and asthma later in life (Reilly & Kelly 2011). Childhood obesity increases risk factors for: cardiovascular disease (high cholesterol, high blood pressure) (Freedman et al. 2007); type 2 diabetes (high blood glucose) (Von & Hewett 2007); orthopaedic problems (bones, joints); and sleep apnoea (Centres for Disease Control and Prevention 2012). Type 2 diabetes, once thought of only as an adult chronic disease, is increasing in prevalence due to the rising obesity rates in children and adolescents (Von & Hewett 2007).

Social and psychological impacts of overweight and obesity throughout childhood are also significant, including depression, anxiety, eating disorders, victimisation, discrimination, teasing, bullying, stigmatisation (Russell-Mayhew et al. 2012; Strauss & Pollack 2003) and negative effects on self-esteem and self-image (Cornette 2008). As found within a large European study of 17,159 children and adolescents aged 8-18, excess weight in childhood can negatively impact upon health-related quality of life, particularly physical well-being and self-perceived quality of life (Ottova et al. 2012). This is concerning, as shown within one Australian longitudinal study, that BMI and health-related quality of life both track throughout childhood (Williams et al. 2011).

2.1.2 Chronic disease risk behaviour tracking

Reducing the global burden of chronic diseases such as obesity is a high priority, with recommendations for prevention efforts to take a life course approach by
targeting physical inactivity and unhealthy diets (International Association for the Study of Obesity 2012). This approach looks at the long term effects of physical and social environmental exposures, during key developmental stages, which accumulate across the life span (gestation, childhood, adolescence and later in life) and influence chronic disease development (Ben-Shlomo & Kuh 2002). The prenatal stage is a risk period for babies gaining excess body fat whose mothers are obese and/or develop gestational diabetes during pregnancy (Kim, Sharma & Callaghan 2012), whilst early childhood is a risk period when eating and PA habits and trajectories develop (Birch, Savage & Ventura 2007). The transition from adolescence to young adulthood has been identified as a risk period for dieting and unhealthy weight control behaviours leading to excess weight gain (Neumark-Sztainer et al. 2012). This risk is also identified earlier, where the period from childhood to adolescence is of time of increasing independence and exposure to multiple environmental and social influences on behaviour (Esposito et al. 2009).

The following section presents key health behaviours associated with obesity; namely, PA, sedentary and eating behaviours, in relation to recommendations, adherence, and tracking through childhood.

**Physical activity**

PA, a key modifiable obesity risk behaviour, is critical for weight management and bone health during development (Boreham & McKay 2011). To achieve health benefits\(^2\), a minimum of 60 minutes moderate-to-vigorous daily PA (MVPA) is recommended throughout childhood and adolescence (Department of Health 2014b; Department of Health and Human Services 2014), however cross sectional studies show a declining trend in participation rates. Objectively measured U.S. data reveals a decline in PA of around 38 minutes per year over a six year period (Nader et al. 2008), with only 3% (girls) and 12% (boys) meeting

\(^2\) _It should be noted that these recommendations are sufficient for healthy weight maintenance, not weight loss._
PA recommendations in early adolescence (age 12-15), a notable decline compared to the 35%-48% of younger children (aged 6-11) who meet the same recommendations (Troiano et al. 2008). Whilst not as dramatic as the U.S., PA levels in Australian children also show a downward trend in the period from childhood to adolescence. Seventy-six per cent (girls 71%; boys 80%) of children aged 9-13 met recommended guidelines, based on 2007 self-reported PA data from a nationally representative sample (Department of Health and Ageing 2007). These children engaged in an average of 144 minutes MVPA per day, which declined by an average of 10 minutes per day for each additional year of age (Department of Health and Ageing 2007). At age 14-16, the number of adolescents meeting MVPA guidelines was much lower at 58% (girls 51%; boys 64%). Consistent patterns were found in a study using data from 32 countries, with self-reported MVPA levels in all countries declining from age 11 to 15, with girls engaging in less activity than boys (Borraccino et al. 2009). Longitudinal evidence reveals a similar pattern, indicating that these patterns are not solely explained by cohort effects. A recent review of 16 child/adolescent cohorts (European/U.K., Canadian, American, Australian), showed evidence of a decline in self-reported PA over a 5-8 year period, with tracking weaker in females than in males (Craigie et al. 2011). Organised (e.g., school physical education) (Lee et al. 2007) and non-organised PA (e.g., over school recess and lunch) (Ramstetter, Murray & Garner 2010) are seen as important for children’s overall physical and social health, yet also decline during childhood. In a longitudinal study of 1,293 children from early (age 12-13) to later adolescence (17-18), both organised and non-organised self-reported MVPA were subject to the same rate of decline of 8% per year (Bélanger et al. 2009).

This widespread decline in PA from early childhood through adolescence has been attributed to several diverse factors (Katzmarzyk et al. 2008), including environmental influences (home/family, school), psychological factors, health status (Brodersen et al. 2005), type of activity (Bélanger et al. 2009), declining active transport (McDonald 2007), land use/design, transport options (Booth, Pinkston & Poston 2005) and peer influence (Jago, Page & Cooper 2012). For
example, children with positive interpersonal characteristics may be more likely to engage in PA with their peers (Brodersen et al. 2005).

**Sedentary behaviour**

Further to engaging in a minimum amount of daily PA, to reduce health risks children should minimise the amount of time being sedentary (such as sitting or lying down, other than sleeping). Sedentary behaviour is not just the absence of PA, but an independent construct and predictor of obesity (Sisson et al. 2009). National guidelines recommend breaking up times spent sitting, and limiting recreational electronic screen time which contribute to low energy expenditure (e.g., watching TV/videos/DVD’s, playing non-active computer games, net surfing), to no more than two hours per day (Department of Health 2014b; Tremblay, LeBlanc, Janssen, et al. 2011). However there is a high prevalence of children exceeding this recommendation. Almost half of a representative sample of the U.S. population of children aged 2-15 spent more than two hours a day in screen time, with older children engaging in more screen time than younger cohorts (Sisson et al. 2009). Results of an Australian study revealed that screen recreational time for adolescents aged 11-15 averaged 4-6 hours per day (NSW Government 2011). Systematic reviews of longitudinal studies show that sedentary behaviours are somewhat stable and track moderately through to adolescence (Biddle et al. 2010; Craigie et al. 2011), which is a concern given the high prevalence within childhood.

Excessive sedentary behaviour, particularly TV viewing, is positively associated with an unhealthy diet (Pearson & Biddle 2011), inadequate PA (Tremblay, LeBlanc, Kho, et al. 2011) weight gain (Jago et al. 2005; Must & Tybor 2005), and reduced physical and psychosocial health (Tremblay, LeBlanc, Kho, et al. 2011). However further longitudinal evidence is needed, with one systematic review of prospective studies concluding there is insufficient evidence to demonstrate a positive relationship between sedentary time and obesogenic risk factors (Chinapaw et al. 2011). The combination of contributing factors that give rise to
Sedentary behaviour is complex. One longitudinal study found no association between weight gain and sedentary screen time in children aged 8-15, suggesting screen time does not have an independent effect on weight status (Kwon et al. 2013). Further, children aged 10-12 who live in socio-economically disadvantaged environments have been shown to be less physically active and engage in more screen time than those with higher socio-economic status (Ball et al. 2009). Conversely, high levels of sedentary behaviour and PA can also coexist in children of this age (De Bourdeaudhuij et al. 2012).

**Eating behaviour**

A global shift in children’s food choices and diet towards energy-dense refined foods high in fat and sugar, such as fast food and sweetened beverages, has displaced healthier food choices like fruit and vegetables and is a major contributor of excess energy intake and increasing childhood obesity prevalence (Chopra, Galbraith & Darnton-Hill 2002). Food-store density and location (Booth, Pinkston & Poston 2005) and socioeconomic status (Wang & Lim 2012) are also contributing factors, influencing food availability and access to energy dense diets. A low fibre diet (Ventura et al. 2009) and skipping breakfast (Alexander et al. 2009; Tin et al. 2011) may be further obesity contributing dietary behaviours.

Alongside adequate PA, an energy balanced diet is recommended for achieving a healthy weight and chronic disease prevention (World Health Organization 2014). This includes limiting energy intake from total fats and sugar and increasing consumption of fruit, vegetables, legumes, whole grains and nuts (World Health Organization 2014). For children over two years of age, national guidelines recommend a minimum number of daily serves of fruit/vegetables. U.K. guidelines recommend children consume five portions of combined fruit/vegetables (Department of Health 2011), while Australian guidelines recommend a minimum of two serves of fruit and 5 - 5 ½ serves of vegetables (National Health and Medical Research Council 2015b). Australian dietary guidelines also stipulate limiting intake of discretionary foods (i.e., food and
drink containing saturated fat, added salt, and added sugar), rather than providing a measure of maximum intake (National Health and Medical Research Council 2015a). However, national dietary survey data in Australia, the U.S., and the U.K. shows poor adherence to fruit and vegetable recommendations and excessive intake of discretionary foods, with dietary quality apparently declining as children age. Within the U.K., just 13% boys and 7% girls aged 11-18 years met portion guidelines for fruits and vegetables (Department of Health 2011). Fruit consumption by Australian children declined markedly at each age bracket: 61% of children met serving guidelines at age 4-8; 51% at age 9-13; dropping to only 1% by age 14-16 (Department of Health and Ageing 2007). Vegetable intake was also poor, ranging from 22% to 14% to 5% of children meeting serving guidelines by age group respectively (Department of Health and Ageing 2007). An Australian study of 3,245 primary and secondary school children found that frequent discretionary food consumption was positively associated with poor quality dietary patterns (characterised by insufficient fruit and vegetable intake and excessive discretionary food intake) and weight gain (Innes-Hughes et al. 2011).

Evidence of dietary intake tracking through childhood is limited, although longitudinal evidence shows a decline in diet quality over time, again indicating that these age-related changes are not simply cohort effects. For example, the Bogalusa Heart Study in Louisiana (U.S.), showed decreased fruit intake and increased sweetened beverage and salty snack consumption from age 10 to young adulthood (19-28) (Demory-Luce et al. 2004). Similarly, a decline in fruit intake was found in a Dutch study of 168 participants from age 12 to adulthood, with males more likely to meet recommended intake than females (te Velde, Twisk & Brug 2007).

Amenable behaviour and the period from childhood to adolescence
The above evidence highlights three notable tendencies. First, there is a general decline in MVPA and dietary recommendation adherence throughout childhood,
in conjunction with increasing obesity prevalence. Longitudinal evidence indicates that this is due, at least partially, to developmental differences. These findings emphasise the need for interventions within childhood to improve these health behaviour trajectories and subsequently reduce chronic disease risk later in life (Craigie et al. 2011). Second, evidence shows that obesogenic behaviours also track through childhood, i.e., that children who engage in these behaviours are likely to continue to do so throughout adolescence and into adulthood. This demonstrates the importance to intervene at key developmental stages to alter the obesogenic trajectory and improve healthy weight behaviour. Third, consistent declines in healthy behaviour (MVPA, diet) (Borraccino et al. 2009; Department of Health and Ageing 2007; Nader et al. 2008; NSW Government 2011; Troiano et al. 2008) and an increase in sedentary screen time (Sisson et al. 2009) were seen over the period from late childhood to early adolescence, suggesting this is one such critical life stage for targeting increases in behaviours for promoting healthy weight and reduction in chronic disease risk. The period from late childhood to adolescence will be the focus of the remainder of this review.

2.2 Childhood to adolescence

The following section will look at the childhood to adolescence life stage from a social-ecological perspective, for an understanding of influences on obesogenic behaviour to identify potential leverage points for change. The transition from primary to secondary school will be a particular focus of the impact of changing environments (physical, social) on behavioural change.

2.2.1 ‘In between’ life stage

For the purposes of this review, the transition from childhood to adolescence encompasses the period of pre-adolescence to early adolescence, approximately 10-14 years of age. Childhood to adolescence is generally defined by overlapping
age and/or developmental stages. These include pre-pubescent (4-12); pre-adolescent or pre-teen (10-12); early adolescent (11-13 or 11-14); and teenager (13-19); or alternately middle childhood or primary school age (6-12) and adolescence (12-18) (Dacey, Travers & Fiore 2009). ‘Tween’ is a more colloquial term as an abbreviation of ‘tweenager’, the stage ‘in-between’ child and teenager, approximately 10-12 years of age (Oxford Dictionary 2013). In school terminology the ‘middle years’ generally refers to students aged 10-15 in school years 5-10, but can also refer to fewer years within this range (Chadbourne 2001).

Childhood to adolescence is associated with significant change: psychosocial; physical (Boyd & Bee 2012), particularly puberty (Perry 2012); emotional, cognitive, and social (Zimmer-Gembeck & Skinner 2011) with increasing influence from peers (Brown 2004). Changes in appearance (height, weight, body fat, muscle development) brought on by puberty onset and varying by age and sex, can be a difficult and emotional period affecting lifestyle choices of diet and physical exercise with a resulting risk of unhealthy weight/development (Perry 2012; Rogol, Clark & Roemmich 2000). And for children in many countries, including Australia, this period is also associated with a change of physical and social environment as students’ transition from primary/elementary to secondary/high school (Department for Children 2008).

Transition environment and obesity
The childhood-adolescent transition is important to understand from a socio-ecological systems context. The socio-ecological approach to health identifies various levels of influence on behaviour, from personal characteristics to contexts and environments in which the individual lives and is exposed to (Bronfenbrenner 1977). From a public health perspective, intervening at different levels can potentially increase intervention effectiveness, whilst not understanding the complex nature of these contextual influences may produce unintended consequences of the desired behaviour change (Scholmerich &
Kawachi 2016). As established within the principles of the Ottawa charter for health promotion, the environment has a major influence on health and health-related behaviour (World Health Organization 1986). The interrelationship of individual, social and environmental factors impacting upon eating and activity behaviours has been described as a complex and dynamic system contributing to the problem of obesity (Finegood 2009; Huang et al. 2009). A system in this context is defined as an interrelated grouping of people, processes, activities, settings and structures functioning as a whole to produce an emergent effect different to the effect of individual system components (Foster-Fishman, Nowell & Huilan 2007). A system is also described as dynamic, being more than a linear input-process-output chain, consisting of relationships, linkages, interactions and feedback loops that unfold over time (Hawe, Shiell & Riley 2009). These perspectives are portrayed within an obesity causal map, developed by specialists from a wide range of disciplines commissioned to review the U.K. obesity epidemic, which comprises 34 integrated maps of 108 interrelated variables (e.g., organisational, social, food production, etc.) and 304 causal links that ultimately influence energy input and output of an individual (Foresight 2007). (Figure 4 demonstrates this complexity in a difficult to read interwoven map.) That is, not one but multiple adaptive systems, made up of a large number of heterogeneous elements interacting with each other to advertently or inadvertently effect eating and activity behaviours that determines weight status over time.
Figure 4 Foresight obesity causal map

An easier to read depiction of system influences impacting upon energy balance, weight and health (not specifically within childhood/adolescence) is shown in the U.K. National Institutes of Health (2004) ecological model (Figure 5).
Figure 5 Ecological model of diet, physical activity and obesity

Throughout childhood and adolescence the home/family (Bauer, Berge & Neumark-Sztainer 2011), social/peer (Salvy et al. 2012) and school community environments (Story, Nanney & Schwartz 2009) are principal influences impacting on the development and maintenance of individual dietary (Birch, Savage & Ventura 2007), sedentary (Hancox & Poulton 2006) and PA behaviours (Verloigne et al. 2012). With an emphasis on change over the childhood-
adolescent transition period, this review will further focus on the importance of peer and school environments and their influence on behaviour change.

**Peer influence**

Peers play an important role in child and adolescent development (Rubin, Bukowski & Parker 2006), associated with positive well-being, social connectedness and a desire for acceptance (Wigfield, Byrnes & Eccles 2006). Peer influence becomes more prominent in pre-early adolescence, as children spend more time with and identify more with their friends (Brown 2004). For example, as shown in a 2.5 year longitudinal Australian study of social behaviours in early adolescent girls, time spent ‘hanging out’ and talking with friends, watching TV/videos and playing computer games increased over this period (Hardy, Bass & Booth 2007). Peer influence appears to be strongest between age 10-14, with increasing autonomy and independence stronger in later adolescence (Steinberg & Monahan 2007). This suggests pre to early adolescence may be a critical time to engage the influence of peers for promoting and modifying healthy behaviour.

A significant amount of research has been conducted identifying peers as a major influence on deviant behaviour in adolescence, particularly smoking (Seo & Huang 2012), alcohol and drug use, violence (Tomé et al. 2012) and sexual risk behaviour (Voisin, Hong & King 2012). More recently there has been a focus on the role of peers towards an understanding of promoting positive health behaviour. For example a recent review found various peer mechanisms influencing engagement with PA in children and adolescents (aged 10-18), including friendship support, peer norms and peer acceptance (Fitzgerald, Fitzgerald & Aherne 2012).

The role of friendships in relation to social influence on obesity and obesogenic behaviour will be further explored in Part 3: ‘Social influence and networks’ below.
The school environment

School is an important setting not only for formal education, but also for personal development and social relationships (Ruini et al. 2009). Friendships contribute a feeling of belonging within the school environment, in addition to having a positive (Vaquera & Kao 2008) and/or negative effect on academic performance (Juvonen 2006).

Intervention is ideally suited around the school environment, considering the amount of time children spend at school and the potential for promoting health benefits for students and the wider community (Buijs 2009). There are few studies of obesity interventions in school settings specific to the childhood-adolescence transition period, an important life stage for obesity prevention. The majority of studies focus on age ranges within childhood (<= 12 years) or adolescence (>= 12 years) separately. Of the few interventions that do address the transition years and target PA, sedentary and/or eating behaviour, most are conducted in middle schools, generally in the U.S. or Europe. For example, a large U.S. multicomponent, subsidised school lunch program targeting obesity prevention in middle school children was able to improve academic performance and maintain normal BMI levels over a two year period (Hollar et al. 2010), whilst increasing vegetable intake was a short term result of a nutrition education program conducted in three Italian middle schools (Amaro et al. 2006).

PA interventions in middle schools have produced mixed results, particularly in relation to gender. One large (25,000 students) multicomponent environmental (curriculum, policy, social marketing) U.S. study significantly increased MVPA levels in boys over two years, but not in girls (McKenzie et al. 2004; Sallis et al. 2003), whilst another U.S. multicomponent (educational, social marketing) study produced a small increase in girls MVPA levels over two years, but with no change in body fat percentage (Webber et al. 2008). Clemmens and Hayman (2004) noted inconsistent results in their review of multicomponent studies with adolescent girls, finding that interventions were more effective when reducing
sedentary behaviour was also incorporated into the study design. Only two studies within this review incorporated peer-led intervention components, which found significant PA increases for adolescent girls in the short term. A notable gap is the limited amount of interventions incorporating peer components when targeting this age cohort. Research has also tended to focus on particular school environments (i.e., middle or primary or secondary school), rather than the key transition between school environments.

2.2.2  Primary to secondary school

A change of school environment over the childhood to adolescent transition is a very significant and often difficult milestone that can impact upon academic performance and general health and well-being (Duncan 2012; Zeedyk et al. 2003). The primary-secondary school transition is a major shift from a familiar to an unfamiliar environment bringing multiple change including: a different curriculum, larger school size, more teachers, subjects, rooms, homework, and responsibilities (e.g., managing timetables) (Chedzoy & Burden 2005; Wassell, Preston & Jones 2007; Zeedyk et al. 2003). Of further significance is changing peer groups, making new friendships and adjusting to belonging to the youngest cohort (secondary school) after being at the highest year (grade) level in primary school (Pratt & George 2005).

The school transition from primary to secondary differs within and between countries for age of entry and school year level. Within the U.S. school years over the childhood-adolescent transition can include elementary/primary (year 5 or 6; age 10-11 or 11-12) to middle (year 6; age 11-12) or high/secondary school (year 6 or 7; age 11-12 or 12-13) (U.S. Department of Education 2005). With the recent introduction of a national curriculum, all Australian states and territories are to be aligned to have the same primary (to year 6; age 11-12) and secondary (from year 7; age 12-13) public school year levels from 2015 (Department of Education 2011).
The transition from primary to secondary school includes major changes in domains of academic, physical and social environments. Most students manage the transition between these school environments and adapt well (Gillison, Standage & Skevington 2008; Nottelmann 1987; Vaz et al. 2015). A small U.K. study found incremental improvements in quality of life measures of autonomy, competence and relatedness (feeling of connection with others) following the primary-secondary school transition (Gillison, Standage & Skevington 2008), and a recent Australian study found students’ sense of belonging in secondary school were similar to when in primary school (Vaz et al. 2015). However not all children transition successfully and a considerable amount of research predominately concentrates on mental/emotional/social health and/or the success or otherwise of academic attainment. Common themes include students at risk, resilience, self-esteem (Bailey & Baines 2012; Jindal-Snape & Miller 2013; Tilleczek 2008; West, Sweeting & Young 2010; Yadav, O’Reilly & Karim 2010) and social support (Akos 2002; Bru et al. 2010; Ganeson & Ehrich 2009; Jindal-Snape & Foggie 2008; Martinez et al. 2011). A poor transition can: have negative impacts on psychosocial (Yadav, O’Reilly & Karim 2010); emotional and mental health (Waters et al. 2012); contribute to behavioural problems (West, Sweeting & Young 2010); lead to truancy and becoming unsettled (Yadav, O’Reilly & Karim 2010), and for some, an increased risk of not completing secondary education (Tilleczek 2008).

The education system recognises the importance of a successful transition, adopting strategies to help students familiarise with and feel comfortable in their new environment (Department for Children 2008; Department of Education and Early Childhood Development 2011; Department of Education and Training 2015). These include primary school student visits to secondary school, using similar material/curriculum in years 6 and 7, having a ‘buddy’ system with older secondary school students (Department for Children 2008; Department of Education and Early Childhood Development 2011; Department of Education and Training 2015), and introducing year 7 health assessments (in the U.K.) for early identification of potential problems (Duncan 2012). Some student concerns
when facing the transition to secondary school include anxiousness about meeting teachers, being the only child from their primary school, getting lost in secondary school (Ashton 2008), bullying, low self-esteem, peer relationships, having external support networks (Tilleczek 2008; Topping 2011), and an increased workload (Zeedyk et al. 2003). These fears were further documented within an Australian longitudinal study of 3,459 students aged 11-14, which found negative social expectations prior to attending secondary school were predictive of victimisation, low peer support and low school connectedness after the school transition (Lester et al. 2012). Social support for coping and providing a feeling of confidence is seen as crucial for a successful transition (Jindal-Snape & Foggie 2008; Tilleczek 2008), which is particularly sought from friends and peers (Akos 2002; Ganeson & Ehrich 2009). Whilst most research over the school transition has focused on academic or psychological outcomes, many student concerns/stress about unsuccessful transitions has to do with peer relationships.

School transition and physical health

Whilst there is a relatively large body of research on psychosocial health over the school transition, little research has explored the impact of the school transition on physical health or health behaviours, which are very much intertwined with social and psychological factors. Differences in primary and secondary school canteen systems and policies providing different food options can affect dietary intake (Drummond & Sheppard 2011), for example in school systems like Australia where school meals are not provided, yet there is no known evidence of the effect of a shift of school environment on dietary intake in late childhood to early adolescence. PA levels can be impacted from a change of transport mode to and from school, with one Australian study finding that more primary than secondary school children were being driven to school (Carver, Timperio & Crawford 2013). PA engagement can also be influenced by physical education curriculum and school environments, which differ between primary and secondary school, such as the allocation and availability of resources (space, equipment, etc.) (Capel, Zwozdiak-Myers & Lawrence 2004). PA perceptions also vary prior to the school transition, with some students feeling less motivated and
less confident (Warburton & Spray 2008), whilst others believe physical education would be more about developing skills and be less fun than when in primary school (Dismore & Bailey 2010). Although obesity risk behaviours change during development (often for the worse as reviewed earlier), there is very little research on the potentially important role of the school transition specifically, on behaviour change.

Emerging evidence of the impact of the shift of school environment across the primary to secondary school transition generally shows a decline in MVPA, with context-specific variations. Objectively measured school break (recess and lunch) MVPA was shown to significantly decline over a five year period over the school transition in one Australian study, which also found a corresponding increase in sedentary time (Ridgers et al. 2012). A decline in extracurricular within-school and total weekday PA (self-report) was also found within a Belgium study two years after the transition to secondary school, yet objectively measured weekday MVPA increased over this period (De Meester et al. 2014). No comparative assessment was made of weekend MVPA within this study. A further study, with students from 23 U.K. primary schools, which found objectively measured after-school MVPA declined within the year following the transition to secondary school, also showed weekend MVPA to increase (Jago, Page & Cooper 2012). An increase in MVPA was found to be positively associated with an increase in the number of friends and friendship support, suggesting a peer influence effect on behaviour over the school transition. With different measures and different contexts making comparison between studies difficult, further evidence is needed on the impact that a shift of school environment has on obesogenic behaviour (dietary, PA, sedentary) within and outside of school, and the mediating psychological, social, and/or environmental factors.

Childhood to adolescence summary

The period from childhood to adolescence is a significant life-stage, often coupled with a disruptive change of physical and social environment over the transition from primary to secondary school. There are indications that the
school transition has an effect on PA decline, yet evidence is sparse and appears inconsistent. There is also very little, if any, evidence of a school transition effect on diet and sedentary behaviour over this period. The social environment is an increasingly important determinant of health behaviours within this life-stage that has often been ignored in past research, and is likely to be especially relevant towards explaining changes in obesogenic behaviour during this stage. Social influence on behaviour will be the focus of the next section.

2.3 Social influence and networks

The following section will first introduce social influence theories for an overview of potential peer influence mechanisms on behaviour in adolescence. The systems science method of social network analysis will then be introduced as a way of identifying and understanding peer influence mechanisms on behaviour change over the school transition. This will then be followed by existing social network evidence of peer influence on obesity and related behaviour.

2.3.1 Social influence theory

Peer influence becomes more pronounced as children enter adolescence (Dacey, Travers & Fiore 2009), explained by various theories of underlying and related social influence mechanisms. Social learning theories propose that individuals adopt behaviours through modelling, imitation and observation of peers valued by the individual (Bandura 1977). Similarly, social normative influence is the adoption of behaviour to conform to others for peer group acceptance, whether the behaviour is desirable to the individual or not (Aronson, Wilson & Akert 2005). For example, the development of anti-social behaviour norms (e.g., dishonest behaviour amongst peers) in elementary school has been shown to be associated with more anti-social and negative behaviour (e.g., apathy, being unkind to peers) during middle school (Galván, Spatzier & Juvonen 2011; Masten, Juvonen & Spatzier 2009).
Brechwald and Prinstein (2011) in their review of social influence theories and processes, found no one particular theory explained all peer influence effects of why adolescents adopted or conformed to peer group behaviour. Multiple social influence mechanisms (i.e., normative influence, modelling, imitation, etc.) were found to give rise to peer influence in adolescence (Brechwald & Prinstein 2011). They also highlight a number of important adolescent and peer factors that are potentially important in explaining peer influence, such as the depth of relationships. Close/best friends who understand the individual have been shown to be more important for psychological health than the broader peer group (Wilkinson 2010). In a study comparing cohesion (i.e., having strong personal relationships) with structural equivalence (i.e., having similar social position), the behaviour of best (cohesive) friends was found to be more important for determining deviant adolescent behaviour within a school environment (Berten & Van Rossem 2011).

Social influence as an important factor in adolescent health behaviours, is generally evidenced through the adoption of behaviour of peers via various mechanisms of normative influence, social learning, modelling/imitation and/or motivations to conform, which result in similar behaviour between peers (particularly close friends). Another important process that gives rise to similarity in behaviour is social selection by homophily, where homophily is the tendency for individuals to select and associate with others who are already similar to themselves in some way (e.g., attitudes/behaviour) (Brechwald & Prinstein 2011). Social selection is an important precursor to social influence to consider, i.e., adolescents select peers with similar traits, then behaviour through social influence mechanisms (e.g., modelling) become even more similar (Steglich, Snijders & Pearson 2010).
Social influence theory and obesity related behaviour

Given the social nature of PA and eating behaviour and the strong influence of peers within adolescence, understanding how peer mechanisms influence these behaviours is needed for designing effective interventions to promote healthy weight behaviour for the prevention of obesity (Salvy et al. 2012).

Peer group norms, impression management (altering behaviour to make an impression on others) and modelling mechanisms, have all been implicated to influence overweight status, eating and PA behaviours within children and adolescents (Salvy et al. 2012). Social norms can be a mechanism for friendship selection, with peers befriending others of similar weight (Schaefer & Simpkins 2014). This is also a pathway for social marginalisation, where non-overweight adolescents isolate overweight peers from not being selected within friendship groups (Schaefer & Simpkins 2014).

Various mechanisms have been implicated to effect the amount of food eaten in the presence of others, including social facilitation (eating more when in groups), modelling (eating similar quantities as others), and impression management (eating less to make an impression on others) (Herman, Roth & Polivy 2003). Salvy et al. (2009) also found that conveying a certain impression may depend upon weight status, where 9-15 year old overweight youths did not eat as much in the presence of non-overweight peers compared to eating with overweight peers.

Descriptive norms (perceptions of others behaviour) of friends PA were found to be the strongest predictors of an individual’s own PA within a study of adults (Priebe & Spink 2011). Whilst descriptive norms may be biased due to people believing they are more similar to others than they actually are, perceptions may be just as important a mechanism for predicting behaviour than actual constructs.
2.3.2 Social network analysis

Social network analysis (SNA) primarily describes and defines social structures (Wasserman & Faust 1994) that are comprised of patterns of social relationships, which differ in their composition, purpose and size, and can range from a small group of individuals up to hundreds, thousands or even millions of ‘relationships’ whose connections are facilitated by online social networking media such as Facebook and Twitter³ (Dunbar 2012). These structures can be described and analysed at different levels: that of the individual (ego or personal network); dyad (pair of actors); triad (group of three actors); subgroup; and entire (or complete) network. Social network theory builds upon these methods to understand the functions and effects of social networks. For example, theories of network homophily whereby people who are similar are likely to be socially connected in a network because “birds of a feather flock together” (McPherson, Smith-Lovin & Cook 2001), and how social networks influence individual and group perceptions, behaviours and attitudes (Friedkin 1998).

Specifically, SNA is based on graph theory, mathematics, and statistics, where networks are described in terms of the patterns of relationships (connections or ties) among social entities or ‘actors’ (e.g., people, organisations, groups) (Wasserman & Faust 1994). ‘Ties’ within a network are representations of interpersonal (or inter-organisational) relationships where the quality of relationship is measurable and quantified according to the research question (e.g., friendships, email communications, monetary transactions, romantic relationships, alliances/collaborations, bullying/aggression, etc.). SNA is a formalised analytic method to describe (numerically and visually) relationship patterns towards an understanding of individual and collective outcomes or behaviours (Hanneman & Riddle 2005). For example, Figure 6 is a visual representation of a network with twelve individuals connected (or otherwise) by line (tie) indicating a specified relationship between pairs (dyads) of individuals.

³ Twitter’s vice president of engineering disagrees with Twitter being labelled as a social network, preferring instead the term ‘information network’ (Needleman 2012)
Through relational ties that link social entities (actors), network analysis can be used to describe: (1) roles of individuals within a network relative to other actors (e.g., if an actor is central or isolated); (2) structures of local subgroups of actors (e.g., local communities and cliques, clustering coefficients); and (3) structures of entire networks (e.g., density, reachability, and centralisation/hierarchy of the overall network) (Hawe, Webster & Shiell 2004). The ability to measure and mathematically describe patterns of relationships within complex social systems.
makes SNA a suitable methodology for measuring social environments (e.g., peer interactions, supports) and evaluating how they impact upon behaviour and influence population health (Luke & Harris 2007). Using Figure 6 (Social network diagram example) data for examples, Table 1 gives an overview of some common network metrics by structural level: that of the individual (ego or personal network; level 1); sub-structure (level 2); and complete network (level 3).
Table 1 Levels and examples of structural social analysis measures

<table>
<thead>
<tr>
<th>Level of analysis</th>
<th>Measure</th>
<th>Description</th>
<th>Example from Figure 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level 1: Individual: ego-centric (personal network)</td>
<td>Network size</td>
<td>Number of other nodes (alters) that ego shares a relationship (undirected) with</td>
<td>Node A has 5 members within their personal network (nodes B, C, D, E, H)</td>
</tr>
<tr>
<td></td>
<td>Composition</td>
<td>Prevalence of a particular network characteristic</td>
<td>80% of A’s personal network is male</td>
</tr>
<tr>
<td></td>
<td>Density</td>
<td>% of all possible ties between alters that are observed ((no. of undirected ties between alters)/(n * n-1))</td>
<td>The density of A’s (undirected) personal network is 30%, based on the number of ties among the 5 members of their personal network</td>
</tr>
<tr>
<td></td>
<td>In-degree</td>
<td>The number of ties directed to a node (e.g., friendship nominations received)</td>
<td>Node A has 5 in-degree nominations (B, C, D, E, and H). Node A has the highest in-degree than any other individual within the network.</td>
</tr>
<tr>
<td></td>
<td>Out-degree</td>
<td>The number of ties directed from a node (e.g., friendship nominations made)</td>
<td>Node A has 3 out-degree nominations (B,C,D)</td>
</tr>
<tr>
<td></td>
<td>Centrality</td>
<td>Prominence of an individual node based on measures of in-degree (e.g., a measure of popularity)</td>
<td>Node A is the most central based on their in-degree (5) and connection to other high in-degree nodes (e.g., node E)</td>
</tr>
<tr>
<td>Level 2: Sub-structures &amp; sub-groups</td>
<td>Dyad</td>
<td>Pairs of tied individuals</td>
<td>K-L, I-J, etc.</td>
</tr>
<tr>
<td></td>
<td>Triad</td>
<td>Group of three tied individuals</td>
<td>EFG, BCD, etc.</td>
</tr>
<tr>
<td></td>
<td>Clique</td>
<td>Structures of three or more individuals who share a defined proportion of ties with one another</td>
<td>ABCD are a fully connected clique, who are all connected to one another</td>
</tr>
<tr>
<td>Level 3: Network (as a whole)</td>
<td>Density</td>
<td>% of actual ties out of all possible ties between nodes (n*n-1)</td>
<td>19% actual connections of all possible connections (in a directed network)</td>
</tr>
</tbody>
</table>

*Source: Hanneman & Riddle (2005)*
SNA provides analytic tools to describe social network structures (examples listed above), as well as statistical models to test network hypotheses. Network data are inherently independent due to explicitly measuring relationships, therefore traditional statistical approaches that make assumptions about data independence are often not appropriate. Random sampling methods can be applied when collecting *personal network data*, and this can be modelled using traditional statistical approaches (e.g., linear regression (Crossley et al. 2015)), however this is not appropriate for obtaining complete network data, which requires a census of a defined and bounded social group (e.g., a census of all students in a school, and the relationships they have to one another) (Prell 2012). Generalisability can be a limitation with complete network approaches, because to generalise beyond a focal complete network can be labour intensive and expensive, requiring a sample of multiple complete networks (Valente 2010; Willis et al. 2012). Studies therefore typically take a census of one or two complete networks (e.g., school based). Statistical network models (e.g., Exponential Random Graph Models, and Stochastic Actor-based models/SIENA models) have been developed for cross sectional and longitudinal complete network data which explicitly model dependencies in the data to accurately test network hypotheses (e.g., in relation to relationships between triads within a network) (Lusher, Koskinen & Robins 2013; Snijders et al. 2006).

Confounding effects are known to be an important issue for studies that draw conclusions of social network effects on individual attributes or behaviours, highlighting the need to account for and model other potential explanations that can result in dependencies between network ties and actor outcomes. These include social selection processes (e.g., based on homophily), the influence of shared environments, and other shared predictors (e.g., age and gender). For example, a study with a large representative sample of U.S. adolescents using social network methods, found that adolescents were more likely to ‘get’ headaches if their friends had (a contagion/diffusion effect), results which after adjusting for confounding (e.g., school-level fixed effects) became non-significant (Cohen-Cole & Fletcher 2009). However, SNA is a rapidly developing
field continually evolving to overcome limitations of earlier applications (Prell 2012). Confounding can be addressed with a strong theoretical study design and use of appropriate statistical network models.

SNA has a history of applications within social and behavioural sciences as a tool for analysing social structures, including political systems, community networks, social supports and group problem solving (Wasserman & Faust 1994). Within public health, SNA has been applied within a wide range of areas including: analysing patterns of disease transmissions in social groups (Emch et al. 2012); information diffusion within public health organisations (McAneney et al. 2010); and examination of centrality of public health systems (Wholey, Gregg & Moscovice 2009). SNA methods have also been applied towards understanding social mechanisms on health risk behaviours, including network effects on smoking behaviour (Christakis & Fowler 2008; Seo & Huang 2012), and personal network influences on alcohol and drug substance use (Costenbader, Astone & Latkin 2006; Green et al. 2013; Wenzel et al. 2010). This approach extends research of interpersonal (e.g., dyad, small social groups) influences on behaviour, and gives us a more holistic perspective of how characteristics and features of broader social systems influence these behaviours. Using social network analysis towards an understanding of social influence on 1) obesity and 2) obesity related behaviour is an emerging and promising area of research, which will be discussed next.

2.3.3 Social networks and obesity

Before discussing social network studies in adolescence and/or childhood, it is important to note a prominent paper on social networks and obesity by Christakis and Fowler (2007). This study on adult social (sibling, spouse, family, and peer/friend) influence has been instrumental for further research challenging and/or exploring links between the social environment and obesity as a public health problem. Using longitudinal SNA with data from 12,000 adults
over 32 years (from the Framingham Heart Study (Dawber, Meadors & Moore 1951)), this study reported that individuals who had adult siblings, a spouse, and (in particular) friends who became obese, were at increased risk of also becoming obese themselves. Their analysis led them to conclude (1) there is a social influence on (positive and negative) weight status (based on peer influence on weight norms, rather than direct peer influence on behaviour), and (2) obesity spreads through social networks (Figure 7), i.e., obesity is socially contagious (Christakis & Fowler 2007).

![Figure 7 Spread of obesity within adult networks 1975 to 2000](Source: Christakis & Fowler 2007)

The suggested explanation is that weight gain in others may influence an individual’s own weight norms, in turn influencing their weight-maintenance behaviour and risk for becoming overweight. This hypothesis was tested in a study that compared individual weight relative to heavier and lighter populations, which found that people were less concerned about their weight when they compared themselves to heavier people (Knecht, Reinholz & Kenning 2007). Within a population of increasing average weight, a potential outcome of this scenario is a change in people’s reference points for what is perceived as normal weight and/or obese, perpetuating population obesity levels (Hammond & Ornstein 2014). Critiques of the Christakis and Fowler paper question the methodology applied for measuring networks, the treatment of confounding effects such as social selection and endogenous network processes, and the
resulting conclusion that obesity is contagious and influenced by people ‘three steps removed’ (Lyons 2011). This invited further exploration of the effect of social networks on weight status and related behaviour using a growing suite of network methods and new advances in social network models. Nonetheless, the proposition that obesity may be socially contagious sparked a great deal of public health interest, and implies that both the context (social environment) and type of social network (particular characteristics) would need to be considered in any attempt to use social influence to change perceptions of weight and/or health behaviours.

Adolescent social networks and obesity

The suggestion that obesity is socially contagious has also been explored in adolescent populations (and to a much lesser extent in children). A number of studies used data from the U.S. National Longitudinal Study of Adolescent Health (Add Health), a large study following a cohort of adolescents from age 13-18. Beginning in 1994-95 (initially using in-school questionnaires and followed up with in-home interviews one, six and thirteen years later), the study capitalised on the first two data collections which incorporated information on school-based friendship nominations and self-reported weight and height (Carolina Population Centre 2012). The first two waves of data, one year apart, were used in a number of studies to longitudinally investigate possible social contagion (and/or marginalisation) effects of overweight within adolescent school-based friendship networks.

Network analyses using Add Health data (Ali, Amialchuk & Rizzo 2012; Simpkins et al.; Strauss & Pollack 2003; Trogdon, Nonnemaker & Pais 2008) and a smaller separate study (of students aged 11-15) (Valente et al. 2009) were consistent in their findings that friends (i.e., adolescents who were connected by a friendship tie in the network) shared similar weight status (BMI). Thus, overweight adolescents were more likely to have overweight friends (Valente et al. 2009), and this was true particularly for females (Trogdon, Nonnemaker & Pais 2008).
Studies using the Add Health dataset also found evidence of social marginalisation of overweight compared to non-overweight adolescents (i.e., overweight adolescents received significantly fewer friend nominations) (Schaefer & Simpkins 2014; Strauss & Pollack 2003). Social isolation and low peer acceptance is a concern in adolescence, where it can contribute towards the development of psychosocial and behavioural problems (Klima & Repetti 2008; Valente et al. 2009), as well as lead to high energy intake and physical inactivity (Salvy et al. 2012); the latter particularly a concern for those who are ostracised because of excess weight. Lower BMI was found to be associated with high social trust and positive social networks in an Australian study on neighbourhoods of children aged 8-9 and adolescents aged 12-15 (Veitch et al. 2012). Although this study concluded that positive social environments may be an important factor in obesity prevention in youth, mechanisms explaining the BMI/network relationship were not determined (Veitch et al. 2012).

Weight similarity among socially connected youth in a network could be attributed to several mechanisms: 1) social influence on weight norms, that in turn leads to similar weight; 2) social influence on weight-related behaviour, that in turn leads to similar weight; 3) social selection, whereby youth become friends/socially connected because of similarities in weight status, common behaviours/activities, or preferences to befriend peers with similar demographics or attributes that may be correlated with weight status; and/or 4) the exposure of socially connected peers to the same cues and environments that impact risk for overweight. The majority of studies using Add Health data finding evidence of obesity contagion, where similarity of weight between social connections increased over time, did not account for the different confounding mechanisms that could also account for weight similarity. One study which did analyse various mechanisms, found evidence that adolescents selected friends with similar weight status, and that friends weight status influenced adolescent weight status over time (Shoham et al. 2012). Similarly, an Australian longitudinal cohort study found weight similarity arose via the selection of friends of similar weight, but did not find evidence of social influence on weight
status (de la Haye et al. 2011a). To further explore social mechanisms on weight status, a number of studies have begun to look at the effect of peers on weight related behaviour in adolescence, as important determinants of health behaviours at this life-stage, which will be discussed next.

2.3.4 Social networks and obesity related behaviour

Emerging evidence reveals various levels of friendship influence on PA, sedentary (Fitzgerald, Fitzgerald & Aherne 2012; Macdonald-Wallis, Jago & Sterne 2012; Sawka et al. 2013) and dietary (Fletcher, Bonell & Sorhaindo 2011; Sawka et al. 2015) behaviour, generally differing by type of behaviour and by gender. A number of recent social network studies have examined the effect of peer influence on obesogenic behaviour in late childhood and early adolescence (Table 2). More than half (9 of 15) are cross sectional in design, with the majority analysing network associations with PA (12 of 15).

Table 2 Summary of recent peer influence studies in late childhood and adolescence by behaviour type

<table>
<thead>
<tr>
<th>Behaviour</th>
<th>Design (number of studies)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cross Sectional</td>
</tr>
<tr>
<td>Dietary</td>
<td>1</td>
</tr>
<tr>
<td>Physical activity</td>
<td>3</td>
</tr>
<tr>
<td>Physical activity and screen</td>
<td>3</td>
</tr>
<tr>
<td>Physical activity, screen and dietary</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>9</td>
</tr>
</tbody>
</table>

Using complete network or personal (ego) level analyses, these studies have found varying associations of similarities and friendship influence with some PA, eating and sedentary behaviours (Table 3). Friendship selection was also incorporated into some analyses to distinguish between behaviour similarity arising from the selection of friends with similar behaviour/attributes, and the similarity of behaviour arising from friendship influence on behaviour.
<table>
<thead>
<tr>
<th>Study (&amp; purpose) by behaviour type</th>
<th>Design &amp; Sample</th>
<th>Data collection</th>
<th>Measures &amp; network analysis</th>
<th>Findings</th>
<th>Significance / conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salvy et al. (2009)</td>
<td>Clinical trial</td>
<td>Amount of energy dense and nutrient dense food eaten</td>
<td>Mixed regression analysis</td>
<td>Eating with a friend resulted in a greater energy intake than eating with an unfamiliar peer; overweight youth ate more when eating with an overweight partner whether they were a friend of unfamiliar peer</td>
<td>The effect of familiarity may result in greater energy intake, shaping eating habits and behaviour over time</td>
</tr>
<tr>
<td>To examine the effect of familiar and unfamiliar peers on food intake on overweight and non-overweight youths</td>
<td>USA 42 children aged 9-15 randomly assigned to eat with an unfamiliar peer or a friend</td>
<td>Height and weight measures</td>
<td>Dyadic network data</td>
<td></td>
<td></td>
</tr>
<tr>
<td>de la Haye et al. (2013)</td>
<td>Longitudinal cohort</td>
<td>In-school surveys; 3 data collection waves over one school year</td>
<td>Complete network analysis (stochastic actor-based modelling)</td>
<td>Adolescent intake of low nutrient energy dense food intake was predicted by their friends intake</td>
<td>Social influence mechanism not related to beliefs/perceptions in relation to low nutrient energy dense foods</td>
</tr>
<tr>
<td>To test associations and explore social influence mechanisms of adolescent peers and low nutrient energy dense food intake</td>
<td>Australia 378 year 8 students (age 12-15) from 2 high schools (2 cohort networks)</td>
<td>Food frequency survey from list of 14 foods</td>
<td>Network data: list names of school friends and select best friends, number not specified; only best friend nominations used for analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wouters et al. (2010)</td>
<td>Cross sectional</td>
<td>Food frequency questionnaire of energy dense snacks</td>
<td>Two-level regression analysis</td>
<td>Strong peer association with snack consumption in</td>
<td>Snacking behaviour shared amongst peer groups; high</td>
</tr>
<tr>
<td>Study (&amp; purpose) by behaviour type</td>
<td>Design &amp; Sample</td>
<td>Data collection</td>
<td>Measures &amp; network analysis</td>
<td>Findings</td>
<td>Significance / conclusions</td>
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<tr>
<td><strong>association between adolescent and their peers snack and soft drink consumption</strong></td>
<td>749 adolescents aged 12-18 from 5 secondary schools</td>
<td>and carbonated soft drinks Network data: list maximum of 5 best school friends</td>
<td>Group level network analysis</td>
<td>boys</td>
<td>consumption when snack foods readily available at school</td>
</tr>
<tr>
<td><strong>Physical activity</strong></td>
<td>de la Haye et al. (2011b)</td>
<td>Longitudinal cohort Australia 378 year 8 students (age 12-15) from 2 high schools (2 cohort networks)</td>
<td>in-school surveys; 3 data collection waves over one school year School-based friendships, engagement in (plus attitudes, intention, etc.) moderate to vigorous physical activity Network data: list names of school friends and select best friends, number not specified; only best friend nominations used for analysis</td>
<td>Complete network analysis (stochastic actor-based modelling)</td>
<td>Friendships selected on similarity of physical activity behaviour and attitude (similarity in attitude towards physical activity the strongest predictor); Friends changed physical activity behaviour to be similar to their friends over time; Close friendships can play an important role in behaviour change, controlling for selection (a confounder)</td>
</tr>
<tr>
<td>Gesell, Tesdahl &amp; Ruchman (2012)</td>
<td>Longitudinal cohort USA 83 children aged 5-12 (mean 7.6) from</td>
<td>3 data collection points at 6 week intervals Accelerometers for minimum one hour</td>
<td>BMI calculated on weight &amp; height measures Complete network</td>
<td>No support for association between friendship formation/dissolution and obesity status or Consider restructuring afterschool programs to enable friendships to form between</td>
<td></td>
</tr>
<tr>
<td>Study (&amp; purpose) by behaviour type</td>
<td>Design &amp; Sample Data collection</td>
<td>Measures &amp; network analysis</td>
<td>Findings</td>
<td>Significance / conclusions</td>
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<tr>
<td>afterschool program networks influences their level of physical activity level</td>
<td>2 afterschool care programs</td>
<td>over five days; weight and height measures; parental demographic survey; network survey administered in private interviews</td>
<td>analysis (stochastic actor-based modelling) Models to distinguish between friendship selection and friendship influence on physical activity</td>
<td>physical activity behaviour; Strong friendship influence to change physical activity to similar levels of friends; No association between number of friendships and level of physical activity</td>
<td>inactive and active children for increasing physical activity</td>
</tr>
</tbody>
</table>

Jago et al. (2011)
To examine associations of PA patterns between best friends

Cross sectional U.K.
472 children aged 10-11 from 40 primary schools

Accelerometer derived PA; height and weight
Network data: name and network characteristics (e.g., frequency and location of PA together) of best friend

Analysis of PA data with PA data of participants best friend
Linear regression
Personal (ego)

For girls, MVPA associated with frequency of activity of best friend. For boys, MVPA associated with MVPA of best friend, outside of school

Higher levels of PA associated with PA of best friend; intervention to focus on encouraging friends to be active together

Jago, Page & Cooper (2012)
To examine friendship characteristic associations with changes in PA over the transition to secondary school

Longitudinal cohort U.K.
458 boys & 474 girls aged 10-11 at time 1

2 data collection points, 1 year apart (T1: primary school; T2: secondary school)
Accelerometer derived MVPA
Network data: friendship measures (number of friends, Change of PA and friendship characteristic from time 1 to time 2; analysis of after-school MVPA and weekend MVPA
Regression models
Personal (ego)

An increase in the number of friends associated with an increase in after-school and weekend MVPA after the school transition. Friendship support not associated with change in MVPA

Strategies to promote activity with friends may help minimise a decline in PA after the transition to secondary school
<table>
<thead>
<tr>
<th>Study (&amp; purpose) by behaviour type</th>
<th>Design &amp; Sample</th>
<th>Data collection</th>
<th>Measures &amp; network analysis</th>
<th>Findings</th>
<th>Significance / conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lopes, Gabbard &amp; Rodrigues (2013)</td>
<td>Cross sectional</td>
<td>Self-report PA recall over last 7 days</td>
<td>Similarity of PA between best friend dyads</td>
<td>Moderate significant association of PA intensity between best friends. Reciprocity of friendship not a factor</td>
<td>Need to take into account importance of best friend when promoting PA in adolescence</td>
</tr>
<tr>
<td>To examine influence of the 'best friend' dyad on PA</td>
<td>Portugal</td>
<td>Network data: participate to nominate best friend (not sibling); best friend to then nominate their best friend</td>
<td>Hierarchical linear modelling Dyadic network analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Macdonald-Wallis (2011)</td>
<td>Cross sectional</td>
<td>Physical activity data collected using accelerometers for five days; physical activity self-reported questionnaire</td>
<td>Friendship degree; mean moderate to vigorous physical activity; accelerometer counts per minute</td>
<td>An association of similar levels of physical activity in close friendship groups; social networks more likely to influence higher levels of physical activity intensity than overall physical activity levels</td>
<td>Contributes to body of evidence that school-based friendships are associated with physical activity</td>
</tr>
<tr>
<td>To investigate whether school friends share similar physical activity levels</td>
<td>U.K. 559 children aged 10-11 from 40 (secondary) schools</td>
<td>Network data: identify up to four school friends with level of friendship ratings</td>
<td>Spatial analysis (correlation and regression) Complete network analysis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Simpkins (2013)</td>
<td>Longitudinal</td>
<td>In-school and in-home surveys; two waves of data approximately 1 year apart</td>
<td>Complete network analysis (stochastic actor-based modelling); tests for friendship influence</td>
<td>Evidence of friendship influence on BMI &amp; PA, and friendship selection by homophily</td>
<td>Interventions to incorporate friendship groups to shape group norms</td>
</tr>
<tr>
<td>To examine associations between adolescent friends,</td>
<td>USA Add Health data; 1,896 adolescents,</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Study (&amp; purpose) by behaviour type</td>
<td>Design &amp; Sample</td>
<td>Data collection</td>
<td>Measures &amp; network analysis</td>
<td>Findings</td>
<td>Significance / conclusions</td>
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<td>---------------------------</td>
</tr>
<tr>
<td>BMI &amp; PA</td>
<td>mean age 15.97 years</td>
<td>Self-report height, weight &amp; PA (number of times participated in types of PA over one week) Network data¹: selection of 5 best male and 5 best female school friends</td>
<td>and selection effects</td>
<td>(similarity of BMI and PA levels between adolescent friends)</td>
<td></td>
</tr>
<tr>
<td>Physical activity and screen</td>
<td>Cross sectional Canada 1,061 adolescents, age 11-15 years</td>
<td>In-school survey Self-report (over 7 days) PA and screen time Network data: selection of close friends from class lists</td>
<td>Ego (e.g., friendship nominations) and complete network (e.g., network density) network variables Logistic regression</td>
<td>Positive association between the proportion of active close friends and meeting MVPA guidelines; positive association in boys between network density and screen time</td>
<td>PA and screen time associated with different network characteristics</td>
</tr>
<tr>
<td>Sawka et al. (2014)</td>
<td>Cross sectional USA Add Health data; 2 schools: 624 &amp; 1151 adolescents aged 13-18</td>
<td>In-school and in-home surveys Screen time and active sport behaviours Network data¹: selection of 5 best male and 5 best</td>
<td>BMI from self-reported height and weight Complete network analysis (stochastic actor-based modelling)</td>
<td>Support for homophily (friendship selection) on BMI and playing active sports. No homophily support on screen time; Evidence of social influence on BMI,</td>
<td>Both weight similarity and social influence important for understanding adolescent obesity</td>
</tr>
</tbody>
</table>

¹ Network data: selection of 5 best male and 5 best female school friends.
<table>
<thead>
<tr>
<th>Study (&amp; purpose) by behaviour type</th>
<th>Design &amp; Sample</th>
<th>Data collection</th>
<th>Measures &amp; network analysis</th>
<th>Findings</th>
<th>Significance / conclusions</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sirard et al. (2013)</td>
<td>Cross sectional USA 2,126 adolescents, mean age 14.4 years from 20 schools</td>
<td>Anthropometrics (height, weight) and in-school surveys; Self-report PA and screen time; Network data: selection of up to 3 male and 3 female closest friends; behaviour of friends via survey</td>
<td>Linear regression between behaviour of ego, and friendship network characteristic; Personal (ego) network analysis</td>
<td>For males, MVPA positively associated with MVPA of female friends. No friendship association with screen time. For females, MVPA positively associated with friends MVPA. Screen time positively associated with male friends screen time.</td>
<td>Little comparative evidence using data from ego-centric analysis to obtain friendship data; further evidence needed</td>
</tr>
<tr>
<td>Ali, Amialchuk &amp; Heiland (2011)</td>
<td>Cross sectional USA Add Health data; 3,898 adolescents aged 13-18</td>
<td>In-school and in-home surveys; 8 behaviours: exercise, sport, screen time, sleep, breakfast, fast food, fruit &amp; vegetable servings, and high density snacks; Network data: selection of 5 best</td>
<td>Multivariate regression analysis for friendship network effect of each variable (behaviour); Personal (ego) network analysis</td>
<td>Significant peer effects of active sport, regular exercise and eating fast food; No support for peer influence of other 5 behaviours; Weight related behaviours not significantly associated with BMI</td>
<td>Suggested that eating and exercise social norms have changed, contributing towards the spread of obesity, inferring interventions should target social network behaviours</td>
</tr>
<tr>
<td>Study (&amp; purpose) by behaviour type</td>
<td>Design &amp; Sample</td>
<td>Data collection</td>
<td>Measures &amp; network analysis</td>
<td>Findings</td>
<td>Significance / conclusions</td>
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</tr>
<tr>
<td>de la Haye et al. (2010)</td>
<td>Cross sectional Australia</td>
<td>272 year 8 students (age 13) from 2 middle schools; 113 year 9 students from 1 school (age 14); resulting in 6 school friendship networks: 3 classes x 2 (male &amp; female)</td>
<td>In-school surveys Self-reported frequency of engaging in obesity related behaviour: high-calorie food consumption; physical activity and screen time Network data: selection of close friends, number not specified</td>
<td>BMI calculated on weight &amp; height measures Complete network analysis (stochastic actor-based modelling)</td>
<td>Organised physical activity similar for male &amp; female friendships in 2 of 3 networks; popularity associated with males and organised physical activity and high-calorie food consumption; Gender differences of similar behaviours; female friends similar in screen behaviours; male friends similar in high calorie food consumption; No support for similarity of non-organised physical activity or amount of TV/movies</td>
</tr>
</tbody>
</table>

1. Add Health network data. Due to the number of respondents between waves, not all friendship data was able to be matched longitudinally. Although up to 10 friends could potentially be nominated, only data for 2-3 friends on average was included.
The selection of friends based on physical activity behaviours (homophily by behaviour) did not yield consistent findings between studies. In their longitudinal cohort study of students aged 12-15, de la Haye et al. (2011b) found best friendships formed with students of similar attitudes towards PA, and to a lesser extent, PA behaviour. This relationship was not found in another cohort study (which also found no association between friendships and weight status) within an afterschool program (Gesell, Tesdahl & Ruchman 2012). Comparability is difficult due to different contexts and age ranges. The afterschool program children ranged in age from 5-12 across year levels, whereas the former study was within an older age cohort within the same school year. Despite these differences, studies utilising longitudinal network analysis found consistent evidence that for school-based friendship selection, children changed their behaviour over time, and that behaviour change was predicted by their friends’ behaviours (de la Haye et al. 2011b; Gesell, Tesdahl & Ruchman 2012; Shoham et al. 2012; Simpkins et al. 2013) Friends, particularly close/best friends, were also found to engage in similar levels of various types of PA for both male and female friendship networks. These included participation in active sport (Shoham et al. 2012), regular exercise (Ali, Amialchuk & Heiland 2011) and organised PA (de la Haye et al. 2010) in adolescents; and MVPA in adolescents (de la Haye et al. 2011b; Lopes, Gabbard & Rodrigues 2013; Simpkins et al. 2013; Sirard et al. 2013) and children aged 10-11 (Jago et al. 2011; Macdonald-Wallis et al. 2011). Friendship association with MVPA may be due to involvement in sporting groups, as general activity did not yield the same correlation (Macdonald-Wallis et al. 2011). Being popular was also associated with PA, although this was only shown in boys aged 13-14 involved in more organised PA than others (de la Haye et al. 2010). No supporting evidence of friendship similarity was found for non-organised PA (de la Haye et al. 2010). These results suggest that different features of social networks may be important predictors of PA, including the behaviour of peers (e.g., similar PA level as the individual) and particulars of the individuals network (e.g., closeness of friendship), and so are relevant to understanding peer influence on obesity related behaviour. To-date, other than
similarity of behaviour between friends, particulars of adolescent friendship networks has not been widely examined (Sawka et al. 2013).

For friendship influence on sedentary behaviours the evidence is also mixed, with particular differences by gender (Sawka et al. 2014; Sirard et al. 2013). No supporting evidence for friendship influence on amount of screen time was found in a study applying regression analyses using Add Health data (Ali, Amialchuk & Heiland 2011), whereas a stochastic actor-based analysis, a network methodology that enables modelling of effects of network structure and behaviour simultaneously (Snijders, van de Bunt & Steglich 2010), using the same source data demonstrated a significant likelihood of individuals adjusting their screen time to be similar to their friends screen time (Shoham et al. 2012). A smaller study (272 students) found screen time similarities (video/computer games and internet usage) within female friendships, but not with males (de la Haye et al. 2010). Inconsistency and lack of association may be due to screen time and watching television being predominately home based activities that are not observed in school friendship groups (Ali, Amialchuk & Heiland 2011). With very few comparative studies, clear associations between adolescent peers and screen time cannot be drawn. Increasing usage of social media (Lenhart et al. 2010) within this age group has the potential to significantly increase the impact of peers on home-based screen behaviour, as may be evidenced in further research.

Likewise for PA, friendship influences on dietary behaviours also vary. There is strong and convincing clinical /laboratory evidence of social influence on eating behaviour, what is less clear is how this translates into real world social networks and relationships. There is some evidence that friends’ eating behaviours influence adolescent eating behaviours, but this seems to vary based on the type of food and quality of the social relationships. For example, within a controlled environment, energy intake has been shown to increase when snacking on energy-dense foods amongst friends, particularly when amongst overweight
peers (Salvy et al. 2009). Cross-sectionally, one real-world adolescent study found an association with eating fast food but not high density snacks (Ali, Amialchuk & Heiland 2011), whilst another found friendship associations between snacking for boys only (Wouters et al. 2010). A further cross sectional study using complete network analysis also found friendship associations with low-nutrient energy-dense calorie food intake for males (de la Haye et al. 2010), whereas longitudinally individual intake was predicted by the intake of adolescent friends for both males and females (de la Haye et al. 2013). Similar to screen time, the few school friendship based studies exploring peer influence on dietary intake at this age may be a reflection that dietary intake and influence is also strong within the home environment (Story, Neumark-Sztainer & French 2002).

Most studies test for a specific effect of whether peer behaviour (actual or perceived) predicts adolescent behaviour, with few testing for underlying mechanisms proposed by social influence theories. Most of the evidence for adolescents shows similarity of some behaviours (particularly PA) between best/close friends (where many study designs incorporate analysis of behaviour between friends) (Fletcher, Bonell & Sorhaindo 2011; Sawka et al. 2013; Sawka et al. 2015), with behaviour modelling (Salvy et al. 2009), adopting peer normative behaviours (Macdonald-Wallis, Jago & Sterne 2012), and/or the selection of friends with similar behaviour as likely social influence mechanisms for behavioural similarity (de la Haye et al. 2011b; Simpkins et al. 2013). Behavioural modelling was identified with individuals directly adjusting their behaviour to be similar to more popular students (de la Haye et al. 2010) and between school friends (Gesell, Tesdahl & Ruchman 2012; Macdonald-Wallis et al. 2011). There is also some evidence of other behavioural influence mechanisms amongst peers, including social facilitation processes through peer support and the presence of friends/peers (Fitzgerald, Fitzgerald & Aherne 2012), which likely result in an increase in a particular behaviour when amongst a greater number of friends. Whilst there have been recent interest applying social network methodologies to understand these mechanisms, there is still a
gap in our understanding of processes and nuances that influence PA, sedentary and dietary behaviours in adolescence (Macdonald-Wallis, Jago & Sterne 2012; Salvy et al. 2012; Sawka et al. 2013).

Further evidence is needed to explain behavioural similarities among friends, including friends outside of school (Macdonald-Wallis, Jago & Sterne 2012). Most of the reviewed studies selected within-school friends only (who may also be friends outside of school), yet many behaviours occur outside of school hours (particularly screen time). Further evidence is also needed to understand processes for adopting similar behaviours over time (de la Haye et al. 2010; Macdonald-Wallis, Jago & Sterne 2012). Whilst cross sectional studies can help us to understand behavioural associations with peers, causal inferences cannot be drawn of the social mechanisms driving behaviour change. This type of information can be used to inform interventions harnessing peer networks to promote healthy behaviour (Salvy et al. 2012), such as identifying influential peer leaders and isolated individuals for forming new network ties (Koehly & Loscalzo 2009).

In addition, whilst each of the identified studies analysed friendships/behaviours over different ages from childhood to adolescence, only one study incorporated the impact of a change of school environment on behaviour as students transitioned from primary to secondary school. A U.K. longitudinal study analysed friendship influence on PA over the primary to secondary school transition, which found a positive association for girls between the number of friends and MVPA outside of school hours (Jago, Page & Cooper 2012). No significant peer association was found for changes in PA for boys over the school transition. This study was with students in late childhood (pre-adolescent only), age 10-12, and for peer influence on MVPA only (Jago, Page & Cooper 2012). Of the other longitudinal network-based studies analysing peer influence on behaviour change over time, three studies, two Australian (de la Haye et al. 2011b, 2013) and one U.S. (Simpkins et al. 2013), were with students (from age 12) attending secondary schools, and one U.S. (Gesell, Tesdahl & Ruchman 2012)
were with primary school aged students (age 5-12), without analyses of behaviour over a shift of school environment. There are no other school transition studies for comparison, or in relation to peer influence on dietary or sedentary behaviour. Given that children and adolescents often eat, play and engage in screen activities together, there is much opportunity for social influence on these behaviours from friends. Further evidence of peer influence on obesogenic behaviour is needed over the school transition, an important life event that is often challenging physically (e.g., dislocation), emotionally and socially (Vinson & Harrison 2006), and potentially a critical period of influence on behaviours at a time when peer groups change and new friendships are formed.

The exploration of friendship influences on obesogenic behaviour in adolescence, using social network analytical methods, is a relatively recent field of research. Emerging evidence reveals various levels of friendship influence on PA, sedentary (Fitzgerald, Fitzgerald & Aherne 2012; Macdonald-Wallis, Jago & Sterne 2012; Sawka et al. 2013) and dietary (Fletcher, Bonell & Sorhaindo 2011; Sawka et al. 2015) behaviour, generally differing by type of behaviour and by gender. Most of the research focus is on PA, with less on sedentary or dietary behaviour. Much of the evidence is also based on cross-sectional studies, identifying friendship associations with behaviour, yet not able to identify potential mechanisms of peer influence on behaviour change over time. Longitudinal evidence, including evidence of peer influence over the school transition (where adolescents undergo a shift of school environment that impacts upon their social networks), is lacking.

2.4 Summary

This literature review found obesity and related chronic disease risk behaviours track through childhood and adolescence, which are also amenable to change from multiple socio-ecological interrelated environmental and individual influences. Despite a relative stability in behaviours, there are also key times of
transition and change. The transition from childhood to adolescence, with an increasing role of peers and a major shift of environment over the transition from primary to secondary school, is a significant life stage of change and influence. The social environment, as an important determinant at this life stage, is particularly relevant for understanding peer influence on behaviour change over this period. Social network analysis methods have recently been adopted to understand the impact and social influence mechanisms of friendships on eating, PA and sedentary behaviours, providing evidence of the appropriateness and value of these methods for continued exploration. This gives us a more holistic, broader understanding of the social environment by measuring a range of nuanced characteristics of an individuals’ social environment, and using SNA methods to test how these relate to individual behaviours/outcomes. There is a gap of evidence on the impact on obesogenic behaviour as students undergo a disruptive change in school system transitioning from primary to secondary school. Understanding the impact of this change is important for informing future obesity prevention intervention, and identifying how peer influence can be used to promote healthy behaviour across the school transition.

*Transition periods and events have the potential to be turning points for lifelong behavioural change where development is a process of “continuity and discontinuity, stabilisation and change”.*

*Child psychiatrist M. Rutter (1994)*
Chapter 3: Methods

3.1 Introduction

Each results paper within this thesis provides a description of the relevant sampling, data collection and statistical analysis methods as appropriate to the study. In order to minimise any repetition, the following is not a complete chapter of all methods applied throughout the thesis. This methods chapter provides further detail on 1) school and participant selection and recruitment; 2) instrument selection and composition; 3) data collection procedures; and 4) data management (data entry, cleaning and treatment and network analytic strategy).

3.2 Sample and recruitment

3.2.1 Sample size

The calculated sample size was based on investigating a change in physical activity levels between students attending two different school systems, i.e., 1) students who transition from a primary school in year 6 to a distinct secondary school in year 7; and 2) students who continue their year 6 to year 7 education within a combined primary-secondary school. Within Australia, combined primary-secondary schools may include year levels from Prepatory or Kindergarten years to year 9 or 12. These schools will subsequently be referred to as P-12 type schools. A required sample size of a minimum of 120-160 total year 6 students was calculated to achieve 80% power to detect change in student behaviour between the two school systems. Power was calculated on a 1 to 1.05 change in self-report physical activity intensity of a 5-point ordinal intensity scale (based on behaviour change results of an intervention with year 7 secondary students (Millar et al. 2011)), assuming a minimum of two schools within each school type, and a minimum of two year 6 classes per school. This
required inviting at least 300 year 6 school students (50% P-12; 50% primary),
based on an anticipated 50% Australian school recruitment rate (McCabe et al.
2009), and 80% retention rate over the year 6-7 follow up period (Johnstone
2010), to recruit a minimum of 150 students for retention of at least 120
students (60 P-12; 60 primary) progressing to year 7.

3.2.2 School selection

The school sampling frame was the Victorian government school summary
statistics report (Department of Education and Early Childhood Development
2012), which provided a list of schools and student enrolment numbers by year
level per individual school and type. Year 5 student enrolments per school in
2012 were used as indicative of year 6 enrolments for the following year in 2013.
Year 6 student enrolments (in 2013) were confirmed with schools during
recruitment.

Based on the potential that socioeconomic status has on obesity risk, particularly
for those living in areas of socioeconomic disadvantage (Wang & Lim 2012),
schools were initially selected in areas within Victoria of relatively lower
socioeconomic advantage, i.e., A change of school environment for children
living within these areas has the potential to have a greater impact upon health
behaviour compared to students more relatively advantaged. To minimise any
potential bias between cohorts (Grimes & Schulz 2002), primary and P-12
schools selected were as similar as possible (i.e., using the same selection
criteria) other than the exposure of interest, (i.e., the type of school system).

The school selection process for primary and P-12 schools was as follows (Figure
8):

1. The locality of schools (primary and P-12 separately) within Victoria were
identified by town/suburb and assigned Socio-Economic Indexes For Areas
(SEIFA) Index scores of Relative Socio-economic Advantage and Disadvantage
(IRSAD), using 2011 Australian census data (Australian Bureau of Statistics
SEIFA IRSAD scores are standardised around an average of 1000 where lower scores represent towns/suburbs with relative disadvantage compared to towns/suburbs with higher scores, and higher scores represent relative advantage compared to lower scores. The researcher stratified the schools by quintile, from first (most relatively disadvantaged) to fifth (most relatively advantaged), then selected from the first and second quintiles.

2. Schools were next included or excluded based on enrolments. No schools within the sampling frame had class sizes of more than 35 students (Department of Education and Early Childhood Development 2012). To ensure selected schools included at least two classes of year 6 (as per power calculations), schools with less than 36 year 5 student enrolments were excluded.

3. Where possible, schools with a middle school structure (years 5-8 together) which are termed ‘P-12 schools’ were selected as first priority. This strategy was to keep the exposure of interest (a shift in school system from year 6 to 7) as distinct as possible.

4. To maximise follow up of students transitioning from primary to secondary school longitudinally, primary schools were included where the number of potential secondary school options within the region was relatively low. The state capital suburbs of Melbourne within a 45 km radius of the central business district, and towns with populations greater than 10,000 were therefore excluded. Distances were calculated using ‘as the crow flies’ online website tool (distancefromto 2013). Town/suburb populations were sourced from Australian census data (Australian Bureau of Statistics 2013). Secondary school data were sourced from Victorian government school summary statistics (Department of Education and Early Childhood Development 2012), the Catholic school website (Catholic schools Victoria 2013), and the Victorian independent school website (Independent Schools Victoria 2013).

5. Schools within each list of primary and P-12 schools meeting inclusion criteria were randomised using a random number generator from 1 to 1000. Schools were selected starting with the lowest random number from each list, and invited into the study until the minimum year 6 enrolment criteria was met.
(refer to next section for school recruitment process). This process continued into the 3rd quintile for P-12 schools when the first two quintiles were exhausted. Seven primary and three P-12 schools accepted the study invitation (refer to Table 4 further below for invitation and recruitment rates).

6. Selected primary schools were consulted as to which secondary schools their year 6 students generally attend in year 7. The number of secondary school options for students vary by location, i.e., a choice of at least 2-3 schools is typical in less populated areas, whilst a choice of six or more schools is typical in more populated areas. Identified secondary schools were then invited into the study. Invitation letters included a statement that schools may not be selected into the study (i.e., if feeder primary schools did not consent). If the identified secondary school did not consent, feeder primary schools were excluded and the next primary school (by random number) was invited into the study. One secondary school declined, resulting in the exclusion of one primary school that had previously accepted the study invitation.

7. The initial recruitment of students was relatively low, requiring a review of the recruitment strategy. An opportunity arose to approach a cluster of schools (3 primary and 4 P-12) within one regional local government area, stratified within the first (n=4), second (n=2) and third (n=1) SEIFA quintiles. One school within this region had previously declined when recruiting randomised schools. The remaining six schools accepted the invitation to participate, also requesting other year levels to be involved (for ease from the schools perspective). As such, year 5 students (who were in composite classes with their year 6 student counterparts) were also invited to participate. This provided the opportunity for potential further longitudinal analysis to explore personal network influence on behaviours.
Figure 8 School selection flowchart for primary and combined primary-secondary schools in 2013
3.2.3 **School recruitment**

Recruitment of schools (and students) were conducted over the two school (and calendar) years, 2013 and 2014. Recruitment of all school types (primary, P-12, and secondary schools) was conducted in school terms 3 and 4, from August to November 2013. Secondary school recruitment re-commenced in term 1 the following school year and continued into term 2 until all schools were recruited by June 2014.

Principals of selected schools of each type (primary, P-12 and secondary) were initially contacted by phone and invited into the study. Interested schools were sent invitation letters together with plain language statements, school consent forms and copies of ethics approvals by email (no school requested paper-based copies). (Appendix B contains correspondence to primary schools as a sample (P-12 and secondary school correspondence was almost identical)). Follow up with interested schools by the researcher was made by phone. For consenting schools, the school principal (or nominated personnel) returned the signed consent form by mail, email or to the researcher when the researcher visited the school. In total, 11 primary, 6 P-12, and 31 secondary schools were recruited and participated within the study, with an overall participation rate of 76% (Table 4).
Table 4 School recruitment response by school type

<table>
<thead>
<tr>
<th></th>
<th>Primary school</th>
<th>P-12</th>
<th>Secondary school</th>
<th>Total schools</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of schools invited</td>
<td>14</td>
<td>14</td>
<td>35</td>
<td>63</td>
</tr>
<tr>
<td>No. of schools recruited</td>
<td>12</td>
<td>6</td>
<td>34</td>
<td>52</td>
</tr>
<tr>
<td>School recruitment rate</td>
<td>86%</td>
<td>43%</td>
<td>97%</td>
<td>83%</td>
</tr>
<tr>
<td>No. of schools withdrawn</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>4</td>
</tr>
<tr>
<td>No. of schools participated</td>
<td>11</td>
<td>6</td>
<td>31</td>
<td>48</td>
</tr>
<tr>
<td>School participation rate</td>
<td>79%</td>
<td>43%</td>
<td>89%</td>
<td>76%</td>
</tr>
</tbody>
</table>

1. Two year 5 primary school students in 2013 transitioned to different primary schools to attend year 6 in 2014, requiring recruiting 2 additional primary schools in 2014.
2. This category includes consenting secondary schools in 2013 that did not participate due to no participating students transitioning to the secondary school in 2014.

P-12: combined primary-secondary school

For the majority of schools, study participation was for one phase of the study only (primary schools in 2013 and secondary schools in 2014). For P-12 schools, participation was for both study phase 1 and 2, the first in 2013 when students were in year 6, and the second in 2014 when the same students were in year 7. For schools participating in both years, ongoing contact was maintained (by phone and email) to confirm continued participation, student enrolments, and throughout the data collection process.

3.2.4 Staff recruitment

Post school consent, schools were contacted to arrange times to visit each school for inviting staff (and students) into the study. At each school, the researcher liaised with the nominated contact person (often the year 6 or year 7 level co-ordinator or other personnel nominated by the school principal). For staff, study participation involved the completion of a school environment and capacity paper-based questionnaire. As per the survey design (Appendix C), invited staff were the school principal, up to three teachers (generally nominated by the school principal or contact person), canteen manager/personnel, and school council representative. Invited staff were each provided with an invitation letter, plain language statement, consent form,
questionnaire and reply-paid envelope. Consenting staff were asked to complete the survey and return to the school office for collection by the researcher or returned via mail in the reply-paid envelope. A labelled returns box was placed at the school office for the collection of staff forms and surveys (and parental consent forms as per the next section).

3.2.5 Student recruitment

Students were recruited into the study in two phases. The majority of participants were recruited in phase 1, when all students attended primary school.

Phase 1 (in 2013) recruitment
Following school consent, a suitable class time was arranged with the nominated contact person at each school for inviting students into the study. The researcher explained details of the two-phase study to all students within a class (year 6 at all schools, and year 5 where requested), who were then verbally invited to participate. Students were then provided with an invitation pack containing a plain language statement for themselves, a plain language statement for their parent/guardian, an invitation letter, a parental consent form (Appendix B), and a returns envelope. The parental plain language statement further explained the process for contacting students for phase 2 of the study. This included asking the students (within the year 6 student survey) which school they intended to attend the following year, for later confirming with school personnel. This strategy was to make tracking of students for phase 2 of the study easier and minimise loss to follow up when students attended secondary school.

Within Victoria, study participation for children requires written parental (opt-in) consent for each individual child. As such, students who wanted to participate within the study were encouraged to take home their invitation pack, return the signed parental consent form and place it in the labelled returns box provided. The boxes were covered with coloured paper (pictured) the same as the parental
consent form, and shown to the students for easy identification. Ethics approval was received to offer parental consent forms online, however this was not taken up due to most participating schools not providing online options within their existing parental communication system.

Each school was contacted a week after students were invited, to gauge student response. With school approval where response rates were low, the researcher returned to the school (in addition to collecting returned consent forms), to give a second invitation and remind students to return their forms. This included strategies of having a coloured class target recruitment sheet, and for recruited students to invite their friends to participate with them (with the aim to recruit as complete a network as possible). Within 2-3 weeks following student invitations, all consent forms were collected and times arranged with school personnel to conduct the study with the students. The final 2013 student recruitment rate was 43% (313 consenting from 736 invited students).

Phase 2 follow up and recruitment (in 2014)
Student lists per school for 2014 were compiled based on responses to the question within phase 1 student surveys asking participants which school they intended to attend the following year. Within term 1 2014, schools were contacted to confirm enrolments from the school list of student participants. If consent was not previously obtained from the school that a study participant was to attend that year, the school was also invited (verbally and with an invitation pack as per 3.2.3) to participate. All secondary schools were recruited where possible. Only one school was not contacted, due to the student attending a secondary school outside of Australia in 2014. Letters were written to parents of study participants as a reminder of phase 2 of the study, as well as providing the option to withdraw their child if they chose to no longer participate (no child was requested to be withdrawn from the study). The letters were sent to the respective schools, for distribution by the school teacher/contact to the student to pass onto their parent/guardian.
Due to the likelihood that children will adopt new friends after they transition to a different school, the original recruiting strategy included inviting all nominated friends of participants who were not already study participants, for inclusion into phase 2 of the study. However due to initial low student recruitment rates requiring recruiting many more schools than the original, this strategy would have required more time and resources to implement (i.e., for recruiting and conducting the study) than what was available. As such, the strategy was revised to invite friends of participants from the regional cluster of schools only, due to the higher recruitment rates within these schools that would provide more complete network data. Friends of study participants at these schools were identified from student responses within the social network survey (refer to 3.3.3). Participants were then given an invitation pack to friends they wished to invite. The invitation pack contained the same documents as received by phase 1 participants (in 2013), the only difference was that plain language statements were in relation to study phase 2 only. An additional 29 students were recruited from this process, giving a total of 342 consenting students (Table 5). Not all consenting students participated at both phases of the study.

### Table 5 Recruitment of students per study phase

<table>
<thead>
<tr>
<th>Year recruited</th>
<th>School year level in 2013</th>
<th>Friends recruited</th>
<th>Total students recruited</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Year 5</td>
<td>Year 6</td>
<td>Years 5-8</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
<td>29</td>
</tr>
<tr>
<td>Total</td>
<td>66</td>
<td>247</td>
<td>29</td>
</tr>
</tbody>
</table>

#### 3.3 Instruments

Instruments for the collection of school environment and student anthropometric and behavioural data are described within each relevant results paper. Further details for the selection of measures are outlined within this chapter. Instruments for the collection of school-based data were a school environment and a school capacity survey. Student data collection instruments
comprised a behaviour and social network survey, anthropometric and
accelerometry measures.

3.3.1 School physical activity and food environment

School environment audit questionnaires designed to collect measurable
physical activity and eating environment data, were used within all school types
(primary, P-12, secondary). Environments for comparison/analysis include PA
resources (e.g., equipment, staff, curriculum, space), canteen policy (e.g., type of
food offered), and food policy (e.g., fundraising, fruit breaks, vending machines).

At the time of study design, two questionnaires were identified as appropriate
for use within Australian school contexts to capture the required data for this
study. These surveys were specifically developed for use within an Australian
community obesity prevention study in multiple primary and secondary schools
(Mathews et al. 2008). To enable comparison between school types, the
secondary school questionnaire was selected for use within TranSFORM, due to
the inclusion of a section on food availability, which was modified to include
primary school year levels where relevant (Appendix C). Two additional
questions were also included, one on school electronic computer games policy
and a second on the amount of time allocated for recess, lunch and class periods
during the day. Further details on the composition of the survey are outlined in
papers 1 (Chapter 5) and 3 (Chapter 7).

3.3.2 School capacity

To assess school capacity for engaging with the problem of childhood obesity,
the community readiness tool (Plested, Edwards & Jumper-Thurman 2006) was
identified as appropriate, having being successfully used within school
community settings (Bell et al. 2008; Frerichs et al. 2012; Millar et al. 2013). The
community readiness assessment validated tool, having widespread acceptance
and breadth of application, is designed to provide an assessment of a
community’s understanding, support and preparedness to address a specific issue, by collecting information from a range of informants within a defined community (Plested, Edwards & Jumper-Thurman 2006). The tool has been shown to have a high level of reliability, with consistency of responses among participants, and high inter-rater reliability (one assessment reporting 92% agreement) between scorers (Plested, Edwards & Jumper-Thurman 2006).

Whilst the level of consistency of responses among participants is generally high, the same responses are not expected due to inviting participants with different roles within a community, who would each have their own perspective on the issue in question. A complication with using this instrument within the current study was having limited resources and time constraints to use the tool as originally designed in interview format. Permission was therefore sought (and was granted), by the authors at Tri-Ethnic Centre for use of the tool in survey format. The minimum number of questions from the interview tool, as suggested within the instrument design, were then included within school staff questionnaires with the aim to minimise respondent burden time to complete the survey (refer to Appendix C4 for sample).

### 3.3.3 Student questionnaires

Existing student questionnaires were assessed for appropriateness for implementation within TranSFORM, with children in late primary and early secondary school (approximate age 10-14 years). No one single survey was identified that included questions on PA, sedentary and dietary behaviour appropriate for use within an Australian school system, and which could be completed in less than a school class period (typically 50 minutes), and allowing for time to also conduct measurements, after the inclusion of a social network component. As such, a survey instrument was compiled from four pre-existing validated tools, considering age and context appropriateness, usage and reliability, with questions selected as appropriate to answer the research questions. The survey for year 6 students included an additional question asking which secondary school they expect to attend the following year. After
compilation, the survey was pre-tested with a small convenience sample of primary and secondary school students. Due to using validated measures (and standard sociometric design where students provide characteristics of their friendship networks), the pre-test was conducted to test the amount of time required to complete, rather than for a validation of the instruments. The approximate time for completion of the full survey was 30 minutes. Further detail than what is included within the published papers on the behaviour and network sections of the survey are outlined below.

Physical activity
Whilst there is the potential for reporting bias or missing data, self-report PA is an appropriate method for capturing a range of PA data for children over the age of ten (Dollman et al. 2009). With a focus on the influence of the school environment and friends on PA, surveys within the TranSFORM study included PA engaged within (recess, lunch) and outside of school hours (after school and weekends). Six questions were taken from PAQ-C, a questionnaire designed to assess childrens’ PA levels during the school year (Kowalski, Crocker & Donen 2004). Studies show PAQ-C questions to be a valid measure of general PA levels in children aged 8-14 (Biddle et al. 2011; Kowalski, Crocker & Faulkner 1997), with scaled questions demonstrating relatively stable test-retest reliability scores that are sensitive to gender differences in PA levels (Crocker et al. 1997). Additional questions were taken from the Children's Leisure Activities Survey (CLASS) (Australasian Child & Adolescent Obesity Research Network 2012a) to provide the amount of time students engaged in being ‘very active’. Being ‘very active’ was defined as “playing hard, running, jumping or other physical activity that makes you sweat and your heart beat faster (Kowalski, Crocker & Donen 2004). The CLASS survey, designed to assess PA frequency and duration, was found to have acceptable reliability, consistent for a seven-day recall with 10-12 year old children (Telford et al. 2004). The survey showed poor validity in estimating PA participation overall, with children underestimating time they spent in moderate (21 mins/day) and vigorous (23 mins/day) PA on average. Objective measures were recommended to be used alongside CLASS to assess
total PA behaviour (Telford et al. 2004). The current TranSFORM study assessed both objective (accelerometer) and multiple self-report PA measures accordingly. Four active transport questions were taken from the ‘Adolescent Behaviours, Attitude, Knowledge Questionnaire’, designed for children aged 12-18 and used within a large scale community development intervention (Mathews et al. 2008), in addition to the 2002 New Zealand national childrens survey (Parnell et al. 2003). No further validation or reliability references have been sourced. Whilst it is recognised that there is potential for inaccuracy using self-report measures, the behaviour survey was designed to enable an assessment of any change of usual behaviour after a period of time, rather than attempting to record an absolute accurate assessment of PA intensity (or detailed dietary intake). As such the same survey was to be completed longitudinally, by students when in both years 6 and year 7, enabling a comparison of reported behaviour by the same participants. In total, ten PA questions were included within the student survey.

Screen-based behaviour
One screen-based self-report question on the usual amount of screen time a child spent on a typical school day and weekend, was also taken from the CLASS survey, using the format as outlined above. The type of computer games usage was further distinguished between ‘not very active’ and ‘very active’ screen time.

Eating behaviour
The TranSFORM survey included questions on self-reported eating behaviours (fruit and vegetable intake, energy-dense nutrient-poor snack food and drink consumption) to enable measurement by number of serves for comparison over time. An advantage of this method is the low participant burden (compared to a food diary for example), that is appropriate for children over ten with the ease of completion within a school setting. There is however, a potential for recall and measurement bias. Whilst self-reported eating behaviour does not provide absolute energy or nutrient intake, this method is appropriate for capturing
usual dietary intake which can be ranked by level and frequency at an individual, group or population level (Australasian Child & Adolescent Obesity Research Network 2012b). A relatively low cost method, self-report dietary questionnaires are also frequently used in population studies, and large scale longitudinal designs (e.g., within the Longitudinal survey of Australian children (Edwards 2012)).

Eight of the twelve questions on dietary behaviour within the validated “Eat Well Be Active” questionnaire, designed to measure obesity risk dietary patterns (Wilson, Magarey & Mastersson 2008), and therefore appropriate for the TranSFORM study, were incorporated into the student self-report questionnaire. This tool is designed to measure change in eating behaviours according to the number of daily serves by food category consumed. Assessment is made using a scoring system (refer to Paper 2 for further detail), providing the ability to detect small changes in dietary intake between measurements. A validation and reliability study with Australian school children aged 10-12 years found all scores to have at least reasonable consistency, and acceptable relative validity (Wilson, Magarey & Mastersson 2008). Good test-retest reliability was found for all scores other than fruit and vegetable knowledge. The full survey was estimated to take 20 minutes to complete. Due to the need to incorporate other behaviours within the TranSFORM survey, only questions on dietary intake were included, therefore knowledge and attitude categories were excluded. Categories were kept to a minimum, appropriate to address the research question, and to minimise respondent burden.

Friendship data
Friendship data was collected using a sociometric format, where network data (with a focus on relationships between individuals) is designed to be collected from a defined community (Wasserman & Faust 1994), in this case by friendship group. Reliability of this method for reporting relationships is generally greater for stronger and reciprocated ties (e.g., friendships) than weaker relationships (Marsden & Campbell 1984, 2012). The TranSFORM social network survey
provided students with space to list the full names (and other characteristics, e.g., gender, year level) of their friends they “hang out with the most”, indicating whether each friend attends their school or is a friend outside of school. This name generator method allowing for free recall, is seen as having higher validity for identifying and measuring true relationships than imposing limits on the number of friends, or selecting names from a class list (Marsden 2011). To enable exploratory analyses of various social influences on individual behaviour, for example normative influence and the frequency of interaction with friends, students were asked when they spent time with each friend (from recess, lunch, after school and weekends), and the perceptions of their friends PA level and healthy eating behaviour (refer to paper 3 Methods for further detail).

3.3.4 Student anthropometrics

Objective height, weight and waist circumference measures were collected from students at both study phases to calculate obesity prevalence, (as self-report is not as reliable due to the tendency for children to under-report their own weight) (Beck et al. 2012). Objective height and weight measures were used to calculate age-appropriate body mass index (BMIz) for use as a control variable within analyses. Height and waist circumference data was collected for calculating waist-to-height ratio, as a further measure of obesity status (Weili et al. 2007).

The following instruments were selected as reliable tools for the collection of anthropometric measures in children and adolescents: portable Charder HM200P height stadiometers, portable A&D UC-321 electronic scales (placed on a hard tile as a consistent surface for measuring), and Lufkin W606PM Executive Diameter tape measures. Stadiometers and scales were calibrated prior to usage. Refer to 3.4.3 ‘Student data collection: anthropometrics’ below, for data collection procedure.
3.3.5 **Accelerometers**

Accelerometers provide an accurate and reliable measure of PA type and intensity (Santos-Lozano et al. 2012), and are a validated measure for use with children (Troiano et al. 2008). Whilst accelerometers provide further PA information to self-report, they are relatively expensive, require individual programming and calibration, and there is the potential for missing data through non-compliance. Maximising recruitment and retention rates are therefore important concerns (Audrey et al. 2012). Both objective and subjective data collection methods used concurrently are therefore recommended for describing a broad spectrum of PA measures, such as intensity, frequency & type (Dollman et al. 2009). Considering best practice, TranSFORM collected self-reported PA and objective accelerometer data, for measuring total PA and PA intensity.

Due to availability, the Actigraph GT1M was the accelerometer of choice in 2013. This is a small matchbox sized device, worn on the hip on an elasticised belt (see pictured example), designed to record continuous movement and measure PA at different intensities. It is light weight, can be worn under or over clothes, and is used extensively in studies with children and adolescents. The GT1M accelerometer uses a motion sensor to measure movement on one axis in the vertical plane (ActiGraph LCC, Pensacola, US). GT1M accelerometers were worn by all participants in 2013, but were not available in 2014. Eighteen (10 in working order) GT3X and 34 GT3X+ models were sourced for the second study phase in 2014. Whilst the GT3X and GT3X+ models are able to measure on three axes, only one axis was included within analyses to enable comparisons with prior year GT1M data. In all other relevant aspects (e.g., counts per minute, application of PA intensity cut points), the three models are comparable and interchangeable (Robusto & Trost 2012). However the supply was inadequate for fitting all participants with accelerometers for the second phase of the study.
3.4 Data collection procedure

Students were invited to participate at both study phases by completing the paper-based behaviour and socio-metric survey, having anthropometric measures taken, and (for some students) wearing accelerometers for an objective PA measure (Table 6). Data collection was conducted in school term 4 in 2013 (October to December), and school term 2 the following year (April to June 2014). The following section provides an outline of data collection procedures. Further details are included within the Methods of relevant papers.

Table 6 Student data collection overview

<table>
<thead>
<tr>
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<tbody>
<tr>
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<tr>
<td>Socio-metric survey</td>
<td>All students</td>
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<td>Anthropometrics</td>
<td>All students</td>
</tr>
<tr>
<td>Accelerometer</td>
<td>All students</td>
</tr>
</tbody>
</table>

3.4.1 School communications

Due to the random location of recruited schools within the state, school visits were arranged according to proximity of one another (e.g., for data collection at two schools in one day where possible). The researcher liaised with the nominated school contact person at all recruitment, data collection and follow up stages. Notices were placed in school newsletters (with most schools) advising parents and students when the study was to take place. After recruitment, a list of consenting students was provided to the school contact person and a suitable time was arranged for student data collection (survey, anthropometric measurements, and accelerometer issue), generally over one or
two 50 minute class periods. For one large P-12 type school, a regular class time for data collection was arranged over a period of a number of weeks until all consenting students had participated.

At the completion of data collection, schools were provided with a thank you letter and certificate, and for primary schools, a small monetary contribution towards school sporting equipment. Final reports are to be sent to all schools at the completion of the project (Appendix D).

3.4.2 Student data collection: questionnaires

Upon arrival at a school on the day of data collection, the researcher met with all participating students in a separate supervised room (from non-participating students), as arranged with the school contact person. Names were checked from a list of consenting students to verify who was present or absent on the day. At the start of the allocated class time, the researcher explained the survey, measurement and accelerometer issue process, and reminded students that they could opt out from having any measures taken if they were uncomfortable in any way.

For the first school, the survey process was researcher-led, i.e., each question of the survey was read out by the researcher, who then waited for all students to complete their answer before moving on to the next question. After the completion of the survey, anthropometric measurements of each student were taken. This process created unnecessary waiting periods for both students and research assistants. The process was subsequently modified where there was at least one research assistant to take measurements, to avoid delays at other schools. For all other schools, measurements were privately taken by research assistants with 1-3 students at a time (in accordance with the number of research assistants), whilst the main student group continued with the surveys. Students continued with the survey after they had their measurements taken.
The researcher was present at all times to provide assistance as required and to keep students on track.

Completed surveys were checked by the researcher as they were handed in by each student. For any missing or incorrectly completed questions, the student was asked to complete or make corrections prior to the conclusion of the session.

3.4.3 Student data collection: anthropometrics

Anthropometric measures were taken by the researcher and up to three trained research assistants. The number of research assistants recruited was dependent upon the number of students who were to be measured, and the amount of time allocated by the school to conduct the study (e.g., 2 measurers for a class of 20 students). All study personnel held (and carried with them) an up-to-date ‘working with children check’ in accordance with the state Working with Children Act 2005.

From the list of consenting students, student names were pre-recorded on a data collection sheet per school (Appendix C5), which included their pre-allocated unique identification (ID) number, full name, name of school, time, date, space for three of each type of measure, and allocated accelerometer number (if applicable). All measures were confidential and taken in a separate screened area.

As students were called by name to have their measurements taken, they were asked to confirm their date of birth and their verbal consent. Measurements were not taken if the student chose to abstain (three students chose not to have either their waist circumference or weight measurements taken). Objective anthropometric data were collected in accordance with standard anthropometric methods for children (Davies, Roodveldt & Marks 2001). All measures were taken over clothes, with shoes and any bulky
jumpers/pullovers/jackets removed. Height was measured using a portable stadiometer to the nearest 0.1cm, weight measured to the nearest 0.1kg using portable electronic scales, and waist circumference measured to the nearest 0.1cm using a tape measure. All measurements were repeated and a third measure taken if the first two measurements differed by 0.5cm (for height and waist) or 0.5kg (for weight) or more.

3.4.4 Student data collection: accelerometers

Issue strategy
The accelerometer issue procedure differed slightly between data collection phase 1 and 2, due to the number and source of accelerometers available. In phase 1, accelerometer initialisation and downloading was conducted by the university department where the monitors were loaned from. After confirming data collection dates, a list of student ID’s were given to staff within the department for initialising GT1M accelerometers for each student, with relevant start and end dates. Initialised monitors were collected by the researcher on the day prior to data collection. The initialising process of GT3X and GT3X+ monitors was conducted by the researcher in phase 2. Accelerometer numbers were recorded on anthropometric data collection sheets for matching with each student. Two accelerometer record sheets were maintained: one upon issue (and return) at the time of data collection by school; and one by accelerometer number to keep track of issues, returns and downloading status.

The strategy for the issue and non-issue of accelerometers to students in phase 2 took into consideration practicality, ethics, and feasibility. From a practical and feasible view, the issue of monitors was staggered by school at approximately fortnightly intervals (i.e., to allow for one week of wear, collection the following week, downloading and initialising for the next student at another school). Where possible, monitors were issued to schools with the greatest number of participants to maximise data collection. From a practical perspective, students who wore an accelerometer in phase 1 for the minimum wear time (i.e., with
valid time 1 data), were a priority for issuing accelerometers within the second phase, to enable analysis of differences in PA over time. From an ethical point of view (so as not to exclude other students), all participating students within the school were invited to wear the monitor, regardless whether they had prior valid data or not. Due to limited accelerometer availability when visiting the cluster of schools within one region, no primary school students within the region were issued with accelerometers in phase 2. By the end of phase 2, accelerometers had been issued to 61% of year 7 students.

**Accelerometer issue to students**
After anthropometric measures were taken, students were next issued accelerometers (monitors). The fitting and collection of accelerometers was conducted at the time of survey and anthropometric data collection for efficiency and to minimise time required for school participation.

Wearing instructions were verbally explained to each student as they were issued and fit with an accelerometer. The monitors were to be worn on the elasticised belt around the waist for one week over consecutive days during waking hours, excluding during water activities. Written instructions were also given to the student to take home to their parent/guardian.

**Collection of accelerometers after wear**
As prior arranged with school staff, the researcher returned to the school the following week to collect the accelerometers from each student, and conduct the study (survey, anthropometric measures, accelerometer issue if applicable) with any consenting student who was absent the previous week.

Upon the return of accelerometers, each participant (including those who were not issued an accelerometer) received a thankyou pack (pictured) in appreciation of their participation within the
study. This included a “Go for your life” tote bag, a small token (either a hacky sack, high bounce ball or 4-colour pen), and healthy eating and activity guidelines pamphlets.

**Follow up**

Reminder notices were given to any student who had not returned their accelerometer on time. Follow up was made with the respective school until the monitors were returned to minimise potential loss. An addressed pre-paid express postage bag was left with the school staff member to return the accelerometer back to the researcher when collected from the student.

Upon return, accelerometers were recorded as received, and data was downloaded at the end of each day ready for cleaning and analysis. Upon completion of data collection at all schools, accelerometers were returned to their original source where they were loaned from.

### 3.4.5 Data collection costs

Data collection costs incurred included: printing and stationery, research assistants time, school contributions, student tokens, postage, travel and accommodation (for overnight stays within one region). Phase 1 data collection costs were covered by the university (research assistant, printing, stationery, postage and some incidental costs), and researcher (travel costs). All phase 2 data collection costs, as well as some data entry and statistical analysis expenses, were covered by an external grant (received from the Windermere Foundation SG14-07).

### 3.5 Data management

This section describes the data entry, data cleaning and treatment processes and analysis strategy not outlined within the results papers.
Data records

Survey and anthropometric data were manually entered into relevant computer programs for cleaning, treatment and analysis (Table 7). Accelerometer data were downloaded from each individual monitor for initial analysis using ActiLife 6 software, prior to downloading individual summary data into Stata for further analysis. Cleaned data sets were stored as master files on a Deakin University server, and analyses performed on copied data sets. Original files were copied into Excel format as additional backup. All final analyses were conducted using Stata 12.0 software (StataCorp LP, College Station, US).

Table 7 Source data and associated software for data entry, cleaning and analysis

<table>
<thead>
<tr>
<th>Participant</th>
<th>Data source</th>
<th>Software</th>
</tr>
</thead>
<tbody>
<tr>
<td>School staff</td>
<td>School environment audit survey</td>
<td>Stata</td>
</tr>
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<td></td>
<td>School capacity survey</td>
<td>Excel, Stata</td>
</tr>
<tr>
<td>Student</td>
<td>Behaviour survey</td>
<td>Stata</td>
</tr>
<tr>
<td></td>
<td>Social network survey</td>
<td>Excel, Stata</td>
</tr>
<tr>
<td></td>
<td>Anthropometric measurements</td>
<td>Excel, Stata</td>
</tr>
<tr>
<td></td>
<td>ActiGraph accelerometer</td>
<td>ActiLife, Stata</td>
</tr>
</tbody>
</table>

3.5.1 Data entry

Participants and schools were assigned identification numbers at the time of consent. All surveys were pre-coded upon design. Student behaviour and school environmental audit survey data were entered once into Stata. Participant responses were entered to align with corresponding pre-formatted variables, providing an initial accuracy check. Entries were double checked upon entering, and corrected as needed. Student anthropometric data were entered into Excel from source data record sheets at the end of each day of data collection, and checked for accuracy. If a further measure was required (e.g., if a third measure was not taken, or if a figure looked incorrect), the researcher re-measured the student (upon participant verbal assent) at the school follow up visit.
From the names of nominated friends within participants sociometric surveys, friends of participants were assigned individual identification numbers using class enrolment lists as a cross reference where provided and if required. For phase 2 surveys, nominated friends were initially checked by name against phase 1 lists, and assigned an identification number if not previously assigned. For both phase 1 and phase 2, friendship survey data were initially entered into Excel, once in summary format (e.g., one row per participant, summarising the number of friends, the number of friends by sex, etc.), and once in detail (multiple rows per participant, with each row representing a dyadic pair containing data per nominated friend). This dyadic data was used for analysis of friendships over time (e.g., participants having the same nominated friend at both time points). Cross-checks were programmed into Excel to check the accuracy of the two data sets to ensure totals were the same per participant and per school. Corrections were made as appropriate. A research assistant was employed to help with phase 2 social network data entry, due to the receipt of the aforementioned external grant, with the guidance of the researcher and a written data entry and checking procedure (Appendix C6).

Checked and corrected Excel spreadsheets were downloaded into Stata. Post entry, a 10% randomised check was conducted of all entered survey and anthropometric data to check data entry accuracy against source documents, and corrected as needed.

3.5.2 Data cleaning & treatment

To check for data validity, all data files within Stata were checked for: missing values; duplicate values; values within correct range (e.g., age of student); and consistency of values between datasets (e.g., student ID, date of birth). Data cleaning procedures conducted within Stata were recorded as ‘log files’, containing instructions and outputs of each process. Log files were stored as text files to enable access to records outside of Stata. Commands used were stored.
on ‘do files’ within Stata to enable processes to be re-run as needed. Unless otherwise stated for a particular data type, inconsistent or out of range responses were treated as missing values.

Missing data
Missing data represented item non-response due to either a true negative response (e.g., food not consumed) or missed question (e.g., chose not to answer). Options to treat missing at random values can include omission from analysis, inference, or imputation of estimated values (Stopher 2012). Missing data within food questionnaires (particularly frequently consumed foods) are unlikely to always represent true zero values (Fraser et al. 2009). Zero values were not automatically inferred so as not to introduce bias within the dataset. Inference, the process of inferring a true response to an unanswered question by using a valid response to another related question by the same participant, was applied where possible. Otherwise data was left as missing. It is noted that any treatment by inference must be objective and clearly guided by rules on how values are inferred (Stopher 2012). Inference was only applied to dietary behavioural data where cross checks were available within the same survey. The applied rules of inference are denoted within the dietary section below.

Student demographic data
Where there were date of birth data inconsistencies between parental (from consent forms) and student responses (from surveys), schools were contacted to verify the correct data to record.

Student dietary behavioural data
Dietary intake items were grouped by category (fruit, vegetables, sweetened beverages and non-core foods) with frequency scales (1-5) indicating number of serves and number of times consumed (Wilson, Magarey & Mastersson 2008). Refer to paper 2 for treatment and analysis of these items.
Two sections within the student behaviour survey requested usual dietary intake of some food and beverage items. Missing values were replaced by inference where possible, as per the following rules (Table 8).

### Table 8 Treatment of missing values within dietary survey

<table>
<thead>
<tr>
<th>Condition. If response at corresponding question is:</th>
<th>Rule</th>
<th>Else</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘I don’t eat’ or ‘&lt; 1 serve a day’</td>
<td>Impute 0 to replace missing value</td>
<td>Leave as missing</td>
</tr>
<tr>
<td>Other options given, i.e., &gt;= 1 serve a day</td>
<td>Impute 0 to replace missing value if a response has been given at either recess, lunch or after school</td>
<td></td>
</tr>
</tbody>
</table>

For missing value at questions:

*What do you usually eat/drink ... “either at recess, lunch or afterschool:*
- potato crisps; chocolate; lollies; hot chips; water; fruit juice/drink; soft drink

<table>
<thead>
<tr>
<th>Condition. If response at corresponding question is:</th>
<th>Rule</th>
<th>Else</th>
</tr>
</thead>
<tbody>
<tr>
<td>‘never or rarely’ or ‘&lt; once a week’</td>
<td>Impute 0 to replace missing value</td>
<td>Leave as missing</td>
</tr>
<tr>
<td>Other options given, i.e., &gt;= once a week</td>
<td>Impute 0 to replace missing value if a response has been given at either recess, lunch or after school</td>
<td></td>
</tr>
</tbody>
</table>

For missing value at questions:

*“how often do you ... drink water / fruit juice / soft drink / eat chocolate / lollies / hot chips / potato crisps .. “*

<table>
<thead>
<tr>
<th>Condition. If response at corresponding question is:</th>
<th>Rule</th>
<th>Else</th>
</tr>
</thead>
<tbody>
<tr>
<td>&gt;=1 given as a response for at least one of (usually eat/drink at) recess, lunch or after school</td>
<td>Impute ‘4’ denoting ‘about 4-6 times a week’</td>
<td>Leave as missing</td>
</tr>
</tbody>
</table>

### Student physical activity self-report data

Within the self-report PA survey, students were asked for the number of times they were very active over a school week, with frequency options of 1-5 times. If an individual selected multiple options, the average response was used. After-
school and weekend PA calculations from self-report PA data are provided within paper 1.

**Scoring of school readiness survey**
The community readiness tool categorises questions into six ‘dimensions of readiness’, namely community efforts, community knowledge of efforts, leadership, community climate, community knowledge about the issue, and resources related to the issue (Plested, Edwards & Jumper-Thurman 2006). Within the current survey, ‘community’ refers to the school community, and ‘the issue’ refers to the problem of childhood obesity.

Each response is given a score from 1 to 9, to denote the stage of ‘readiness’, where 1 = no awareness of the issue, and 9 = high level of community ownership. Two scorers independently assessed each survey according to the community readiness guidelines and descriptions, and then met to discuss and give an overall score for each dimension per survey. The majority of scores were either the same or differed by one point between the scorers. To reach consensus, the lower score was taken where scores differed. For any greater difference in scores, the average or lower score was agreed upon. For each school, the average scores for each dimension were then calculated by dividing by the number of respondents per school. An overall stage of readiness score for each school was then calculated by totalling all scores for a school, and dividing by six (the number of dimensions). Due to relatively low responses by some schools and regions, results have not been published. A report will be provided to schools for feedback after the submission of this thesis.

**Accelerometer data**
Cleaning of phase 1 accelerometer data required adjustments for incorrectly coded ID’s. Some accelerometer data was not downloaded, resulting in missing data. An initial check of phase 1 accelerometer data also revealed the data to be spurious. The original data files were re-entered into ActiLife, and checked for
validity. A further check was conducted after phase 2 data was downloaded, providing a reasonableness test of the data. All initialisation and configurations for analysis (including wear time, wear time validation specifics, metabolic equivalent cut points), are described within paper 1.

All other data
The treatment and analysis of data not referred to within this section (i.e., for screen time, anthropometric and school environment data) are described within the relevant published papers.

3.5.3 Network analytic strategy

The original strategy for the analysis of friendship influence on individual obesity risk behaviour was to utilise social network analytical methods for complete network data. However within some schools, student response rates were lower than anticipated. For example, Figure 9 depicts a sub network of 12 student participants (the larger nodes) within one primary school at phase 1. The smaller nodes represent nominated friends, with a line denoting a friendship between students. The recruitment rate at this school was 32% (12 from 37 enrolled year 6 students). Without data from the 28 nominated friends (81% of whom are within the same year level at the same school), the reported network from a class perspective is incomplete. A complete network analysis was therefore not feasible.
Not having complete networks was not detrimental to the study objectives or design. Whilst some analyses could not be conducted (e.g., popularity through receiving friendship nominations), the richness of the data provided by participants was ideal for conducting personal (ego) network analyses. As an example, the participants at the primary school in 2013 from Figure 9 above, transitioned to five different secondary schools the following year. These new networks, shown in Figure 10 below, represent 86 dyadic relationships and a change of 85% of friendship networks from the previous year. With a 99% retention rate of participants from time 1 to time 2, the data was strong to also conduct longitudinal analyses of friendship influence on behaviour over time.
3.6 Dissemination of results

At the time of submission of this thesis, three of the four results chapters have been published in peer reviewed journals. The fourth paper was invited by a journal for submission in a special edition that will be published later in the year. Two Honours papers that were the impetus for designing TranSFORM, were also published during the period of candidature by the candidate (Appendix E), entitled: “Whole of system intervention points for obesity prevention: a case study from a long day care setting” (Marks, Barnett, Foulkes & Allender 2013), and “Using Social Network Analysis to Identify Key Child Care Centre Staff for Obesity Prevention Interventions: A Pilot Study” (Marks, Barnett, Foulkes, Hawe, et al. 2013). Protocols and results from this thesis were also presented at university, international and other (e.g., grant foundation) conferences via seven oral and four poster presentations. (Refer to list of publications and presentations at the start of this thesis for further details).
3.7 Summary

This chapter provided further detail of methods applied within this thesis, without attempting to duplicate what has been reported within each relevant results paper.
Part B: Results

Chapter 4: Introduction

Part B of this thesis presents the TranSFORM study results by publication in peer reviewed journals. Following this introduction, this section comprises four chapters. Each chapter indicates the research question/s addressed within the paper and publication status. Each chapter also includes an authorship declaration statement outlining the contributions of each author, and a copy of the published (or submitted) paper. Papers within the thesis are inserted as published or submitted. As such, reference lists are self-contained and individual references may not necessarily be included within the final reference list of the entire thesis.

At the time of thesis submission, three papers were published in peer reviewed journals, and one submitted for publication. The PhD candidate is the first author of each paper.
Chapter 5: Physical activity, sedentary behaviour and the primary to secondary school transition (Paper 1)

This chapter consists of an authorship statement for Paper 1, a longitudinal cohort study entitled: ‘Changing from primary to secondary school highlights opportunities for school environment interventions aiming to increase physical activity and reduce sedentary behaviour: a longitudinal cohort study’, followed by the manuscript itself.

Paper 1 addresses the following research questions in relation to PA and sedentary behaviour:

RQ1. Do obesity risk behaviours change as children transition from primary to secondary school?
RQ2. Is there greater change of obesogenic behaviour for students who change their school environment?
RQ3. What are the differences between primary & secondary school contexts in relation to children’s PA & food environments?

The status of this paper is: Published
AUTHORSHIP STATEMENT

1. Details of publication and executive author

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<tr>
<td>Jennifer Marks</td>
<td>School of Health &amp; Social Development, Faculty of Health</td>
<td><a href="mailto:mjenn@deakin.edu.au">mjenn@deakin.edu.au</a></td>
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<td>The TRANSFORM Study (Transition, School, Friends and Obesity Risk Models)</td>
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If there are multiple authors, give a full description of HDR thesis author’s contribution to the publication (for example, how much did you contribute to the conception of the project, the design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.)

JM designed and executed the study (conception, methodological design, data collection and statistical analyses). JM drafted, revised and submitted the manuscript with critical revision from co-authors.

I declare that the above is an accurate description of my contribution to this paper, and the contributions of other authors are as described below.  

Signature and date: 10/7/15

Signature Redacted by Library

4. Description of all author contributions

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<td>Professor Steven Allender</td>
<td>Project conception, study design and critical revision of the manuscript</td>
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<td>Dr Lisa Barnett</td>
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<tr>
<td>Associate supervisor</td>
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<tr>
<td>Dr Claudia Strugnell</td>
<td>Data analysis and critical revision of the manuscript</td>
</tr>
<tr>
<td>Statistical advisor and analyst</td>
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</tr>
</tbody>
</table>
5. Author Declarations

I agree to be named as one of the authors of this work, and confirm:

i. that I have met the authorship criteria set out in the Deakin University Research Conduct Policy,

ii. that there are no other authors according to these criteria,

iii. that the description in Section 4 of my contribution(s) to this publication is accurate,

iv. that the data on which these findings are based are stored as set out in Section 7 below.

If this work is to form part of an HDR thesis as described in Sections 2 and 3, I further

v. consent to the incorporation of the publication into the candidate’s HDR thesis submitted to Deakin University and, if the higher degree is awarded, the subsequent publication of the thesis by the university (subject to relevant Copyright provisions).

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<th>Name of author</th>
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<td>Signature Redacted by Library</td>
<td>25/1/16</td>
</tr>
<tr>
<td>Dr Lisa Barnett</td>
<td>Signature Redacted by Library</td>
<td>14/12/15</td>
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<td>Dr Claudia Strugnell</td>
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6. Other contributor declarations

I agree to be named as a non-author contributor to this work.

<table>
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<th>Name and affiliation of contributor</th>
<th>Contribution</th>
<th>Signature* and date</th>
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</thead>
</table>

* If an author or contributor is unavailable or otherwise unable to sign the statement of authorship, the Head of Academic Unit may sign on their behalf, noting the reason for their unavailability, provided there is no evidence to suggest that the person would object to being named as author

7. Data storage

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Changing from primary to secondary school highlights opportunities for school environment interventions aiming to increase physical activity and reduce sedentary behaviour: a longitudinal cohort study

Jennifer Marks¹,²*, Lisa M Barnett², Claudia Strugnell¹ and Steven Allender¹,²

Abstract

Background: There is little empirical evidence of the impact of transition from primary to secondary school on obesity-related risk behaviour. The purpose of this study was to examine the effect of a change of school system on physical activity (PA) and sedentary behaviour in pre-early adolescents.

Methods: Fifteen schools in Victoria, Australia were recruited at random from the bottom two strata of a five level socio-economic scale. In nine schools, students in year 6 primary school transitioned to a different school for year 7 secondary school, while in six schools (combined primary-secondary), students remained in the same school environment from year 6 to year 7. Time 1 (T1) measures were collected from students (N=245) in year 6 (age 11-13). Time 2 (T2) data were collected from 243 (99%) of the original student cohort when in year 7.

PA and sedentary behaviour data were collected objectively (via ActiGraph accelerometer) and subjectively (via child self-report recall questionnaire). School environment data were collected via school staff survey. Change of behaviour analyses were conducted longitudinally i) for all students and ii) by change/no change of school. Mixed model regression analysis tested for behavioural interaction effects of changing/not changing school.

Results: Sixty-three percent (N=152) changed schools from T1 to T2. Across all students we observed declines in average daily moderate to vigorous physical activity (MVPA) (−4 min) and light PA (−23 min), and increases in average daily sedentary behaviour (16 min), weekday leisure screen time (17 min) and weekday homework screen time (25 min), all P<0.05. Compared to students who remained in the same school environment, students who changed school reported a greater reduction in PA intensity at recess and lunch, less likelihood to cycle to/from school, greater increase in weekday (41 mins) and weekend (45 mins) leisure screen time (P<0.05) and greater encouragement to participate in sport. School staff surveys identified that sport participation encouragement was greater in primary and combined primary-secondary than secondary schools (P<0.05).

Conclusion: Transitioning from primary to secondary school negatively impacts on children’s PA and sedentary behaviour, and has further compounding effects on behaviour type by changing school environments.

Keywords: Child, Adolescent, Environment, Behaviours, School transition, Physical activity, Sedentary, Screen, Longitudinal studies
Background

Inadequate physical activity (PA) and excessive screen time in childhood and adolescence are concerning [1,2], because of associations with increased overweight/obesity and related health risks [3-7]. A minimum of 60 minutes moderate to vigorous physical activity (MVPA) per day is recommended for children and adolescents [8,9]. A 32 country study measuring the effect of age on MVPA identified declining prevalence of children meeting MVPA guidelines from late childhood to early adolescence [10]. In the US, MVPA declines on average by 38 minutes per year in children between the ages 9 and 15 years [11], with few children meeting guidelines by age 12–15 [12]. In Australian children aged 9–13 years, daily MVPA reduces by approximately 10 minutes per day per year [13].

Over the same developmental period children also record high and increasing prevalence of sedentary behaviours. More than half (56%) of US early adolescents exceed two hours of screen time [14]. A 2011 national survey of Australian 11–15 year olds revealed an average of 5–6 sedentary hours per day, including 2–3 hours recreational screen time [15]. PA [16] and sedentary [17] behavioural trends developed in childhood continue into adolescence and adulthood, with screen behaviour patterns magnified for children living in socio-economically disadvantaged environments [18], highlighting the need for early intervention.

Consistent calls are made for school-based [19] and system-level interventions [20] to promote healthy weight and related behaviour for both educational and longer term health benefits. Environmental influence on behaviour are well recognised [21] and for many children school is a critical environmental influence. Most school-based interventions target either the primary (junior or elementary) or secondary (high or senior) school setting [22], with a scarcity of evidence on the transition period from one school system to another. For some Australian students (aged 11–13), this transition from year 6 primary school to year 7 secondary school is associated with a complete change of school environment including a move to a different geographic and physical setting. For others attending a combined primary-secondary school system (e.g. Preparatory (age 5) to school year 9 [P-9] or 12 [P-12]), the transition from year 6 to year 7 does not require a change in school.

A change of school environment during childhood/adolescence is a very significant and often difficult milestone bringing multiple physical [23-25], and social changes [26], impacting upon academic performance and general health and well-being [24,27]. Despite the more obvious PA related disruptions of changing PE curriculum, school environment differences [28], and transport modes to school [29], empirically little is known about the impact of changing schools on PA and screen-based sedentary behaviour.

Emerging evidence suggests that the primary to secondary school transition affects MVPA [30,31], although studies have reported contrasting findings. In the UK, a large study over this transition period found a decline in after-school MVPA and an increase in weekend MVPA [30]. In contrast, data from Belgium report that objectively measured weekday MVPA increased, whilst self-reported weekly PA decreased across the school transition [31]. Further evidence is needed to explore the contribution that a change of school has on PA, as distinguished from a general PA decline as children enter into adolescence, for informing areas to target for the promotion of PA in early adolescence.

The period of childhood to adolescence is recognised for declines in PA and increases in sedentary behaviour. Less well understood is the effect of the primary to secondary school transition, which occurs over the same time period and a priori would appear to have potential to impact on these behaviours. In this study we sought to assess: 1. PA and sedentary behaviour (including screen-time) change as pre-adolescents transition from primary to secondary school; 2. Whether students who change schools between year 6 and year 7 experience greater change in these behaviours compared to students who do not change school; and, 3. Differences between year 6 and year 7 PA and sedentary behaviour school environments. We hypothesised that PA and sedentary behaviour change will be greater in students who undergo a change of school compared to students who remain within the same school environment.

Methods

Design and sample

This was a longitudinal study following a cohort of students in year 6, their last year of primary school (age 11–13 years) into year 7, their first year of secondary school, with a change of school system and location as the exposure of interest. We recruited school children across different school types representing two different school transitions. The first transition describes children for whom year 6 and year 7 were conducted in separate schools, both in terms of geography and organisational structure. The second transition describes children who attend the same school for year 6 and year 7 (P-9 or P-12) at the same geographical location and within the same organisational structure. The latter school type will henceforth be referred as a P-12 school to distinguish from a discrete primary or secondary school.

Ethics clearance was obtained from the relevant university Human Research Ethics Committee and permission to approach Victorian government schools was received from the relevant school state authority. The sampling frame comprised all Victorian state government primary schools [32] stratified by a five level indexed socioeconomic scale [33] then divided into two groups by
school type: primary and P-12. Schools from both pools were randomly selected from the bottom two socioeconomic strata and invited to participate by providing written consent. In Australia, with more discrete primary than P-12 schools, it is common for year 6 primary school students to disperse to multiple secondary schools the following year. Secondary schools were selected based on student secondary school enrolments identified at T1, and invited to participate at T2 by verbal and written invitation. Almost all secondary schools that participants transitioned to were in the same geographic and socioeconomic region as the corresponding feeder primary school. Informed consent was received from nine primary, six P-12 and 31 secondary schools. School staff (school principal and three teachers at each school) were invited to participate by completing a school PA environment survey. All grade 6 students at consenting schools were invited to participate, requiring informed written parental consent for each individual.

Parental consent was received for 40% (247/623) of invited students. At T1, 245 students participated in the final term of primary school in 2013 (Oct-Dec), two students not available to participate. T2 was conducted 5–8 months later with 243 participants from T1 (99% retention rate) in term 2 of secondary school (April-June 2014).

Questionnaire
Student self-report behavioural questionnaires were completed at both T1 and T2 within a school class period (approximately 40 minutes), incorporating six PA, two active transport, four screen-behaviour and three school environment questions.

PA 5-point Likert scale questions were taken from the Physical Activity Questionnaire for Children (PAQ-C) [34], a validated tool for measuring PA in children and adolescents [35]. One question asked “how often were you very active” in physical education (PE) classes in the last seven days, on a scale of 1 “I don’t do PE” to 5 “always” where being very active was defined as “playing hard, running, jumping or other physical activity that makes you sweat and your heart beat faster” (excluding walking). Students were also asked what they did “most of the time” at recess and lunch on a scale ranging from 1 “sat down (talking, reading, doing schoolwork)” to 5 “ran and played hard most of the time”. The final three PA questions asked to specify from 0 up to 6 times, “how many times” in the last 7 days right after school, on school evenings, and on the last weekend “did you do sports, dance or play games in which you were very active”. These questions included an added component asking “how long did you usually spend each time? (hours/minutes)” taken from the Children’s Leisure Activities Survey (CLASS), validated as a reliable measure of PA frequency and duration in 10–12 year old children [36]. Self-report duration being very active after school and evenings were aggregated and divided by five to give average weekday for being very active outside of school hours. Self-report duration being very active on weekends was divided by two to give a daily average over the weekend.

Two active transport and three school PA environment questions were taken from the Adolescent Behaviour, Attitude, Knowledge Questionnaire (ABAKQ) [37], designed for use within an Australian school obesity prevention intervention, tested for comprehensibility and reliability [38]. Students were asked how frequent they walked/cycled to/from school (0 to 10 times per week). School environment perception questions of “how much does your school encourage all students to” 1 “play organised sport”, and 2 “be physically active at lunch time?” used a 4 point scale from 1 “a lot” to 4 “not at all”. The third question asked students to rate “the teachers at your school as role models for being physically active” on a 5-point scale from 1 “very good” to 5 “very poor”. School perception responses were reverse scored for analysis.

Screen-behaviour questions used the CLASS format [36] asking students to indicate yes/no “during a typical school day/weekend, what TV/computer activities do you usually do?” from a list comprising: watching TV, playing non-active computer games and using a computer for leisure/fun (e.g. online chatting, internet, Facebook) and homework. Students were also asked to record total hours/minutes spent on school days and weekends against each activity. Self-report duration on a typical school day and weekend watching TV, playing non-active computer games and using a computer for leisure were aggregated separately. Screen-time was capped at a maximum of 8 hours per weekday and 16 hours per two-day weekend as per CLASS guidelines [36]. Average weekday screen-time was multiplied by five, added to average weekend screen times and divided by seven to give an average daily total, then categorised as 1) meeting screen-time guidelines ≤ 2 hours/day; or 2) not meeting guidelines.

A school environment audit survey, designed to assess schools as a setting for promoting PA [38] was completed by school staff, with separate sections for school principals and teachers. School principal surveys comprised seven questions, namely the amount of time allocated to 1) recess, 2) lunch and 3) PE; the existence of 4) PA and 5) electronic devices policies; and student access to 6) indoor and 7) outdoor PA facilities using a yes/no response. School teacher surveys incorporated eleven 4–5 Likert scale PA questions, low scores representing greater adequacy/awareness/etc. and high scores represent a lower rating. Questions were as follows: 1 “What proportion of teachers are aware of the school physical activity policy?”; in the last 12 months: 2 "How good was the schools compliance with this policy?"; How adequate
was the: 3 “area for outdoor play?”; 4 “area for indoor play?”, 5 “sporting and active play equipment”; 6 “How accessible was the sports equipment to all students outside of PE and sport?”; 7 “Rate the strength of the links that the school had with community sporting and recreation organisations and facilities”; 8 “What proportion of teachers at your school acted as good role models by being physically active?”; 9 “How adequate was the cycle storage facilities at your school?”; 10 “The school encouraged participation by all students in sports and other physical activities”; and 11 “How effective was your school at promoting physical activity among students?”. School PA environment responses were reverse scored for changes in behaviour from T1 to T2 and differences in perceptions of school PA environments between school types, differences were assessed using exact McNemar or Bowker paired test of proportions (categorical variables), or paired t-test of means (continuous variables). To explore the differential effect on behaviour between changing/not changing school groups, mixed model regression analyses for longitudinal data were conducted from T1 to T2 after adjusting for accelerometer wear-time and individual scores at baseline. Separate analyses were conducted by gender. To compare school environments in relation to PA and sedentary behaviour, environmental differences were analysed using one-way ANOVA or Fishers exact test of proportions between all three school types. Comparisons between primary and secondary schools (excluding P-12 schools) were conducted using t-tests of means or Fishers exact test of proportions. All analyses were conducted using Stata 12.0 software (StataCorp LP, College Station, US). Missing data were excluded from analyses. Statistical significance was set at P < 0.05 (two-sided).

## Results

### Sample characteristics

Of 243 participants (N = 98 boys; 145 girls) assessed at both time points, 152 students (63%) had changed school; and 91 (37%) had remained at the same P-12 school. Mean age was 12.2 years at T1, 12.8 years at T2. The majority (85%) were born in Australia. Between change of school (CS) and no change of school (NC) groups, mean age in years (CS: 12.3 ± 0.4; NC: 12.2 ± 0.4; NS), sex (male) (CS: N = 58 (38%); NC: N = 40 (44%); NS), Australian born (CS: N = 132 (87%); NC: N = 75(82%); NS) and socioeconomic status (SES) (ICC 0.00; 95% CI 0–0.01) did not differ significantly at baseline. No significant school clustering effects were observed at baseline by age (ICC 0.12; 95% CI 0–0.26) or sex (ICC 0.06; 95% CI 0–0.16).

### Aim 1: PA and sedentary/screen behaviour from primary to secondary school

Minimum accelerometer wear-time criteria was achieved for 194 (80%) students at T1; 128 (82% of students who wore an available accelerometer) at T2. Analysis was conducted from 127 participant paired T1 to T2 data. No significant student differences at T1 were observed between students who did or did not meet valid accelerometer criteria at T2 by age (ICC 0.00; 95% CI 0–0.02), sex (ICC 0.04; 95% CI 0–0.18), school type (ICC 0.00; 95% CI 0–0.02) or self-report PA (ICC 0.0; 95% CI 0–0.02).

Changes in PA behaviour between primary and secondary school are shown in Table 1. Objectively measured MVPA (~4 mins/day) and light PA (~23 mins/day) declined in the six month period from T1 to T2, with minimal change in those meeting the recommended MVPA of ≥ 60 mins/day. Outside of school hours self-report ‘very

### Accelerometry

Objective PA data was collected via the ActiGraph GT1M and GT3X+ accelerometer (ActiGraph LCC, Pensacola, US) [39,40]. The match-box sized accelerometers, worn on the right-hip, were issued to all students at T1 and 157 (64%) of participating students at T2 (due to limited accelerometer availability) to wear over a seven day period, excluding sleep and during water-based activities. T1 intra-class correlation (ICC) analyses were conducted to examine differences between students who did or did not wear an accelerometer at T2.

All accelerometers were initialised to record data at 15 second epochs on the vertical axis for consistency between models [40] and waves. Data was included for analysis using ActiLife 6 software, where minimum wear time was 480 minutes over any three 8 hour days, non-wear time defined as >60 minutes of consecutive zero counts with a 2 minute tolerance for optimal sample size and minimisation of any potential exclusion bias [41,42]. Evenson equation cut points were used to categorise accelerometer measures of metabolic equivalents (METs) on the vertical axis, as: sedentary (<1.5 METs); light (≥ 1.5 to < 4 METs); and moderate to vigorous (≥ 4 METs) [43]. Sedentary time was defined as ≤ 100 counts/min [43]. We conducted analyses on average time (minutes) spent in MVPA, light PA and sedentary time as continuous variables. We also conducted a descriptive analysis on whether recommendations of achieving at least 60 minutes MVPA per day were met, by categorising participants into two groups by meeting/not meeting MVPA guidelines of at least 60 minutes per day.

### Statistical analyses

To check for independence of schools prior to analysis, intra-class correlations were conducted by student age and sex at baseline to examine any school clustering effect. Proportions and means were calculated for student demographic variables with comparisons between students who did/did not change school. To test for
active" PA increased on weekdays (10 mins/day), but remained stable on weekends (~1 min/day; NS). Within a school day, 33% of students increased, whilst 15% decreased the frequency of being very active during formal physical education classes at secondary compared to primary school. Self-report PA results, revealed a significant decline in PA intensity levels at recess (N = 133; 55%) and lunch (N = 142; 60%), and decline in cycling to/from school frequency (~0.7 times/week). There were no significant differences observed in other school PA variables, namely rating teachers as PA role models, encouraging organised sport and PA lunchtime participation.

The number of students who usually watched TV/videos decreased (N = 31; 13%) between primary and secondary school (Table 2), whereas the number of students using a computer for leisure (N = 49; 20%) and homework (N = 64; 26%) increased. Average daily duration spent using a computer for homework correspondingly increased both on weekdays (25 mins) and weekends (12 mins).

Self-reported daily duration spent on screen-based activities for leisure increased on weekdays (17 mins/day) but not significantly on weekends (16 mins/day) from T1 to T2. Overall there was no significant shift in the number of students meeting the recommended maximum leisure screen time of less than 2 hours per day (N = 47, 20% increase; N = 32, 13% decrease). For the 127 participants with valid accelerometer data, total sedentary time increased from T1 to T2 of an average of 16 mins/day.

**Aim 2: Behavioural effects of changing school from T1 to T2**

Mixed model regression analysis results (Table 3) identified more pronounced changes in behaviours among students who changed school compared to students who remained within the same school system from T1 to T2. The regression models show that a change of school was associated with a significant reduction in self-rated Likert scale activity intensity at recess (~1.0) and lunch (~0.9). Students who changed school, particularly girls, were 40% less likely to cycle to or from school than students who did not change school. MVPA, light PA and PE frequency were not significantly different between students who changed/did not change school.

Changing schools was also associated with an increase in leisure screen time on weekdays (42 mins/day) and weekends (46 mins/day), particularly for females (49 mins/day). Conversely, students who did not change schools reduced leisure screen time on weekdays (~9 mins/day) and weekends (~13 mins/day). Other screen based activity (number of students watching TV, playing non-active computer games, using and time spent using a computer for homework) and total sedentary time were not significantly different for students that changed school from T1 to T2.

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### Table 1: Change in physical activity from T1: Primary school to T2: Secondary school

<table>
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<tr>
<th>Categorical variable</th>
<th>Total</th>
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<th>T1 to T2 Increase</th>
<th>T1 to T2 Decrease</th>
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<tr>
<td></td>
<td>N</td>
<td>N %</td>
<td>N %</td>
<td>N %</td>
</tr>
<tr>
<td>Average daily MVPA (accelerometer) by recommendation (1: &lt; 60 mins; 2: ≥ 60 mins)</td>
<td>127</td>
<td>102 80%</td>
<td>8 6%</td>
<td>17 13%</td>
</tr>
<tr>
<td>Frequency being very active in PE class (1: No PE, to 5: Always)</td>
<td>242</td>
<td>126 52%</td>
<td>79 33%</td>
<td>37 15% *</td>
</tr>
<tr>
<td>Do most of the time at recess (1: Sit down, to 5: Run/play hard)</td>
<td>240</td>
<td>65 27%</td>
<td>42 18%</td>
<td>133 55% *</td>
</tr>
<tr>
<td>Do most of the time at lunch (1: Sit down, to 5: Run/play hard)</td>
<td>236</td>
<td>52 22%</td>
<td>42 18%</td>
<td>142 60% *</td>
</tr>
<tr>
<td>School encourages organised sport participation (0: Not at all, to 3: A lot)</td>
<td>242</td>
<td>109 45%</td>
<td>77 32%</td>
<td>56 23%</td>
</tr>
<tr>
<td>School encourages physical activity at lunchtime (0: Not at all, to 3: A lot)</td>
<td>240</td>
<td>101 42%</td>
<td>56 23%</td>
<td>83 35%</td>
</tr>
<tr>
<td>Teachers as physically active role models (1: Very poor, to 5: Very good)</td>
<td>242</td>
<td>101 42%</td>
<td>81 33%</td>
<td>60 25%</td>
</tr>
</tbody>
</table>

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### Table 2: Continuous variable change from T1: Primary school to T2: Secondary school

| Continuous variable | Total | N Mean (SD) 95% CI Mean (SD) 95% CI Mean (SD) 95% CI | p* |
|---------------------|-------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------|
| Average daily (mins) MVPA (accelerometer) | 127 | 51 (18) 49, 55 48 (17) 45, 51 | −4 (13) −6, −1 * |
| Average daily (mins) light PA (accelerometer) | 127 | 219 (39) 212, 225 196 (40) 189, 203 | −23 (33) −28, −17 * |
| Average daily (mins) after-school being very active (self-report) | 237 | 64 (56) 57, 71 75 (67) 66, 83 | 10 (66) 2, 19 * |
| Average daily (mins) weekend being very active (self-report) | 242 | 84 (82) 74, 95 83 (85) 72, 94 | −1 (106) −14, 13 |
| Walk to/from school (0–10 times/week) | 243 | 2.9 (3.8) 2.4, 3.4 3.0 (3.8) 2.5, 3.4 | 0.1 (4.1) −0.4, 0.6 |
| Cycle/scoot to/from school (0–10 times/week) | 243 | 1.2 (2.5) 0.9, 1.5 0.5 (1.6) 0.3, 0.7 | −0.7 (2.6) −1.0, −0.4 * |

CI: confidence interval; MV: moderate to vigorous; PA: physical activity; PE: physical education; SD: standard deviation; * statistical significance at P < 0.05 level. 

p*, test value for difference between T1 & T2 total using paired t-test of means.
Perceptions of the school PA environment were notably different for students who changed school. Changing school had a positive effect on encouragement of organised sport participation compared to not changing school, particularly for girls. Rating of teachers as PA role models also increased for students who changed schools from T1 to T2.

Aim 3: Comparison of school environment by school type

School environment surveys were received from 20 (45%) school principals, representing 33% (2 of 6) P-12 type schools, 78% (7 of 9) primary, and 35% (11 of 31) secondary schools. Returned surveys from 66 (49%) school teachers represented 100% (6 of 6) P-12, 89% (8 of 9) primary and 61% (19 of 31) secondary schools.

The average amount of time allocated to recess at secondary school (23 mins) was significantly less than at primary (29 mins) or P-12 (28 mins) schools (Additional file 1: Table S1). No significant differences were found by school type from school principal response surveys for amount of time allocated to lunch or number of PE classes per week. Few schools reported having a PA policy. All secondary schools reported the existence of an electronic device policy compared to P-12 (0%) or primary schools (67%). Teacher-response surveys suggest adequacy of sport equipment was significantly greater at primary schools compared to P-12, but not secondary schools. Similarly, primary schools reported greater accessibility of sport equipment outside of PE/sport and more adequate cycle storage facilities than P-12 or secondary schools. Both primary and P-12 type schools reported greater encouragement for all students to participate in sport and physical activities than secondary schools.

Discussion

We found support for the hypothesis that decline in activity and increase in sedentary behaviours over the primary to secondary school transition were associated with the level of disruption in school environments. Children who experienced the more disruptive transition of moving to a new school were less active during the school day, engaged in more screen time for leisure and were less likely to engage in active transport than counterparts who remained at the same school.

This study is the first to examine the effect of the school transition on sedentary behaviour and shows that leisure screen time increased in students who changed schools between primary and secondary school and conversely declined in students who did not change school. Our overall average increase of 16–17 minutes screen-time per day, and greater average increase in students changing schools over the transition were greater than that reported in previous literature [15]. There were no significant differences between groups in accelerometer derived average daily sedentary behaviour, suggesting that other specific sedentary behaviours (e.g. sitting reading) declined proportionately in the change of school group as screen time increased. Existing literature also shows that the type of leisure screen time changes as children age, with television viewing becoming less proportionate than computer/internet [44,45]. Our results suggest that developmental changes in screen-based sedentary behaviour in early adolescence may be related to disruptions in school associated environments. Further research is needed for informing potential social-based behaviour change interventions by exploring whether a change of social environment associated with changing schools has an influence.

Table 2 Change in sedentary/screen behaviour from T1: Primary school to T2: Secondary school

<table>
<thead>
<tr>
<th>Categorical variable</th>
<th>Total</th>
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<th>T1 to T2 Decrease</th>
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<tr>
<td></td>
<td>N</td>
<td>N %</td>
<td>N %</td>
<td>N %</td>
</tr>
<tr>
<td>Average daily (self-report) leisure screen time (1: ≤ 2 hrs; 2: &gt; 2 hrs)</td>
<td>239</td>
<td>160 67%</td>
<td>47 20%</td>
<td>32 13%</td>
</tr>
<tr>
<td>Usually watch TV/videos (0: No, 1: Yes)</td>
<td>241</td>
<td>194 80%</td>
<td>16 7%</td>
<td>31 13% *</td>
</tr>
<tr>
<td>Usually play non-active computer games (0: No, 1: Yes)</td>
<td>242</td>
<td>173 71%</td>
<td>27 11%</td>
<td>42 17%</td>
</tr>
<tr>
<td>Usually use computer for homework (0: No, 1: Yes)</td>
<td>243</td>
<td>168 69%</td>
<td>49 20%</td>
<td>26 11% *</td>
</tr>
<tr>
<td>Average daily (self-report) weekend leisure screen time (self-report)</td>
<td>240</td>
<td>135 111%</td>
<td>30 12%</td>
<td>61 13% *</td>
</tr>
<tr>
<td>Average daily (self-report) weekday leisure screen time (self-report)</td>
<td>239</td>
<td>143 121%</td>
<td>30 12%</td>
<td>61 13% *</td>
</tr>
<tr>
<td>Average daily (self-report) weekend homework screen time (self-report)</td>
<td>241</td>
<td>36 49%</td>
<td>30 42%</td>
<td>53 69%</td>
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<tr>
<td>Average daily (self-report) weekday homework screen time (self-report)</td>
<td>239</td>
<td>19 32%</td>
<td>15 24%</td>
<td>26 37%</td>
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<table>
<thead>
<tr>
<th>Continuous variable</th>
<th>N</th>
<th>Mean (SD)</th>
<th>95% CI</th>
<th>Mean (SD)</th>
<th>95% CI</th>
<th>Mean (SD)</th>
<th>95% CI</th>
<th>p*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average daily (mins) sedentary (accelerometer)</td>
<td>127</td>
<td>476 (69)</td>
<td>464,488</td>
<td>492 (86)</td>
<td>477,507</td>
<td>16 (76)</td>
<td>2,29</td>
<td>*</td>
</tr>
<tr>
<td>Average daily (mins) weekday leisure screen time (self-report)</td>
<td>240</td>
<td>135 (111)</td>
<td>120,149</td>
<td>152 (114)</td>
<td>137,166</td>
<td>17 (126)</td>
<td>1,33</td>
<td>*</td>
</tr>
<tr>
<td>Average daily (mins) weekend leisure screen time (self-report)</td>
<td>239</td>
<td>143 (121)</td>
<td>127,158</td>
<td>158 (160)</td>
<td>138,179</td>
<td>16 (164)</td>
<td>5,37</td>
<td></td>
</tr>
<tr>
<td>Average daily (mins) weekday homework screen time (self-report)</td>
<td>241</td>
<td>36 (49)</td>
<td>30,42</td>
<td>61 (64)</td>
<td>53,69</td>
<td>25 (67)</td>
<td>16,33</td>
<td>*</td>
</tr>
<tr>
<td>Average daily (mins) weekend homework screen time (self-report)</td>
<td>239</td>
<td>19 (32)</td>
<td>15,24</td>
<td>31 (45)</td>
<td>26,37</td>
<td>12 (48)</td>
<td>6,18</td>
<td>*</td>
</tr>
</tbody>
</table>

CI: confidence interval; SD: standard deviation; * statistical significance at P < 0.05 level.

p*, test value for change between T1 & T2 total using exact McNemar or Bowker paired test of proportions.

1. Daily screen time capped at maximum 8 hours per day as per CLASS guidelines.
on the type of sedentary behaviour students engage in (e.g. screen-based or non-screen based).

PA duration and sedentary time deteriorate with age [12,13,46] and this study provides nuance to objective [12,46] and self-report [13] studies showing that PA decline is affected differentially by type of school transition. That the primary to secondary school transition in general is associated with a decrease in daily objective MVPA contrasts with a Belgian study [31] which reported increasing overall MVPA and light PA decline. Accelerometer derived MVPA at school recess and lunch breaks have been shown to decline significantly in Australian children aged 10–12 by the last year of primary school [47]. In primary school children, lower PA intensity at recess is also associated with being of low SES [48]. With a lower PA base at primary school for children of a lower SES background, a reduction after commencing secondary school is a concern. Within the UK, longer school recess breaks are associated with greater MVPA in 9–10 year old children [49],

Table 3 Behavioural effects from T1 to T2 by change/no change of school and sex

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Change of school</th>
<th>Change to No change of school</th>
<th>Female to Male</th>
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<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Difference</td>
</tr>
<tr>
<td>Average daily (mins) MVPA (accelerometer)</td>
<td>12</td>
<td>9</td>
<td>2.0</td>
</tr>
<tr>
<td>Average daily (mins) light PA (accelerometer)</td>
<td>−20</td>
<td>−27</td>
<td>7.1</td>
</tr>
<tr>
<td>Average daily (mins) after school being very active (self-report)</td>
<td>12</td>
<td>9</td>
<td>2.0</td>
</tr>
<tr>
<td>Average daily (mins) weekend being very active (self-report)</td>
<td>−10</td>
<td>14</td>
<td>4.4</td>
</tr>
<tr>
<td>Frequency being very active in PE class (1: No PE, to 3: Always)</td>
<td>0.6</td>
<td>0.7</td>
<td>0.1</td>
</tr>
<tr>
<td>Do most of the time at recess (1: Sit down, to 5: Run/play hard)</td>
<td>1.5</td>
<td>1.0</td>
<td>−1.0</td>
</tr>
<tr>
<td>Do most of the time at lunch (1: Sit down, to 5: Run/play hard)</td>
<td>1.5</td>
<td>1.0</td>
<td>−1.0</td>
</tr>
<tr>
<td>School encourages organised sport participation (0: Not at all, to 3: A lot)</td>
<td>0.8</td>
<td>0.8</td>
<td>0.0</td>
</tr>
<tr>
<td>School encourages physical activity at lunchtime (0: Not at all, to 3: A lot)</td>
<td>1.0</td>
<td>1.0</td>
<td>0.0</td>
</tr>
<tr>
<td>Teachers as physically active role models (1: Very poor, to 5: Very good)</td>
<td>0.8</td>
<td>0.8</td>
<td>0.0</td>
</tr>
<tr>
<td>Average daily (mins) weekend leisure screen time (self-report)</td>
<td>32</td>
<td>26</td>
<td>6.0</td>
</tr>
<tr>
<td>Average daily (mins) weekday leisure screen time (self-report)</td>
<td>32</td>
<td>26</td>
<td>6.0</td>
</tr>
<tr>
<td>Average daily (mins) weekday homework screen time (self-report)</td>
<td>32</td>
<td>26</td>
<td>6.0</td>
</tr>
<tr>
<td>Average daily (mins) homework screen time (self-report)</td>
<td>32</td>
<td>26</td>
<td>6.0</td>
</tr>
<tr>
<td>Walk to/from school (0–10 times/week)</td>
<td>0.1</td>
<td>0.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Cycle/scoot to/from school (0–10 times/week)</td>
<td>−0.7</td>
<td>−0.7</td>
<td>0.5</td>
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<tr>
<td>Usually watch TV/videos</td>
<td>0.3</td>
<td>0.3</td>
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<td>Usually play non-active computer games</td>
<td>0.4</td>
<td>0.4</td>
<td>1.2</td>
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<tr>
<td>Usually use computer for leisure</td>
<td>0.5</td>
<td>0.5</td>
<td>1.6</td>
</tr>
<tr>
<td>Usually use computer for homework</td>
<td>0.7</td>
<td>0.7</td>
<td>0.9</td>
</tr>
</tbody>
</table>

95% CI: 95% confidence interval; IRR: incidence rate ratio; MV: moderate to vigorous; OR: odds ratio; PA: physical activity; PE: physical education.

1. Adjusted for accelerometer wear time.

*p test value statistically significant at the P < 0.05 level.
The current study adds new insight to this previous work by exploring the effect of length of recess time on PA in light of the transition. Time allocated to recess was significantly less at secondary compared to primary school, coinciding with a greater decline in PA intensity for students who changed schools over this transition. Lunch time durations were similar by school type, offering no explanation for declining lunch time PA intensity, suggesting that other factors encouraging PA during school breaks may be at play [50]. Previous work within primary schools demonstrates the school environment to explain 40% of recess PA intensity variability [50]. Our data intimates sporting equipment is one such factor, being more accessible at primary than secondary school.

Not all aspects of the transition are negative for PA. Despite no significant change of perception in all students transitioning to secondary school, we found students who underwent a change of school environment (particularly girls) reported an increase in encouragement to participate in organised sport and observed better PA role modelling at secondary school. Although this finding was in contrast to reported staff perceptions, student perception is particularly important to consider, as PA decline in adolescent girls is well documented [51,52].

A change of system is invariably associated with cause and effect self-correcting mechanisms to counteract the impact of change [53]. This is evident in our results comparing behaviour change between the two study groups. Whilst duration in light PA and MVPA declined and sedentary time increased across all participants, there were notable differences by type of activity between those who transitioned to a different school system between primary and secondary school, and those without a change of school. A change of seasonality (from spring/summer to autumn/winter) could provide some explanation for an overall decline in PA [54], more so for adolescent girls than boys [55], but not for between group comparisons. No significant differences in objectively measured PA and sedentary time were shown between change and no-change of school groups. In contrast, significant differences were evident between groups for self-reported PA intensity during recess and lunch breaks and leisure screen time duration. This finding is not explained by the low SES characteristics of participants, which is associated with low PA [56] as the students are from similar SES backgrounds. It is possible that organised sport participation increased within the change of school group, counteracting the effect of a decline in unstructured PA at recess and lunch, as implied by student perceptions of an increase in sport participation and greater PA teacher role modelling in their new school environment. These findings demonstrate that the school environment can moderate PA decline in early adolescence, and identifies areas to target to increase PA participation (e.g. staff training, providing sporting equipment in school breaks). Interventions to increase PA at recess have had some success at elementary/primary schools [57]; this study shows the need to intervene at secondary school breaks is also critical.

This effect of the environmental hypothesis is further strengthened by our finding that those who experienced the more disruptive transition were less likely to ride or scooter to secondary school compared to their time in primary school. Modes of transport differ between secondary and primary school aged children [58,59], a change of school often entailing a dramatic change in geographic location, physical conditions (e.g. road infrastructure) and social support, each known correlates of active transport [59,60]. Cooper et al. [61] reported differential associations of the transition depending on travel modes; MVPA increased in students using active transport in secondary compared to primary school, whereas students who changed to car travel had a reduction in MVPA [61]. De Meester et al. [31] suggest changes in PA and active transport relate to differing emphases by school type, with secondary schools emphasising PA within school hours, compared to an after-school PA focus at primary school. Others have demonstrated a variety of factors contribute to students active transport [62], though none have examined this in terms of the scale by type of primary-secondary school transition.

This longitudinal cohort study achieved a very high retention rate of cohort participants. Almost complete data minimised any potential bias from loss to follow up. Further strengths were the randomisation and independence of primary and P-12 schools at baseline. In addition, the incorporation of both objective and self-reported measures enabled analyses to be conducted by total measure and by periods and type of activity/inactivity. There is a risk of potential bias using self-reported PA measures due to individual perception of intensity and duration. This limitation was partially mitigated by the longitudinal design, with participants responding to consistency of questions at both time points. Unfortunately accelerometer data were only available for 50% of participants at T2, although there were no differences at T1 between students who had valid accelerometer data at T2 and those who didn’t, reinforcing the generalizability of the sample. It is possible that collecting PA data across two different seasons (spring/early summer and autumn/early winter) may have affected PA levels to some extent. However, our collection points were not within extreme seasons i.e. summer to winter, and little seasonal effect has been found previously with Australian adolescent males [55], so seasonality is unlikely to have had a major impact. There was a relatively low response for completed principal-based school environment audit surveys, although analyses were able to be conducted with more complete teacher-derived
school environment data, providing a good indication of the differences in PA school environments for the purposes of this study.

Conclusions

Transitioning from primary to secondary school clearly impacts on children’s PA and sedentary behaviour. Changing school environments results in a greater change in types of behaviour, showing this influential life stage is a critical target for the reduction of unhealthy behaviours. The observed reductions in PA intensity during school breaks between primary and secondary school represents a particular area for intervention. Providing more supportive environment in terms of availability and quality of equipment, role models in the form of staff and lead students, and opportunities to be active appear critical to reduce the impact of this transition. While much has been done to measure physical environments and their associations with health behaviours at different school levels, future research may seek to investigate the impact of social influence on behaviour change over the transition.

Additional file

Additional file 1: Table S1. School PA environment by school type (Primary, Secondary, P-12 Primary-Secondary).

Competing interests

The authors declare that they have no competing interests.

Authors’ contributions

JM designed and executed the study, performed statistical analyses and drafted the initial manuscript. LMB and SA contributed to the study design. CS contributed to the data management and analysis phase. All authors have been involved in critical revision of the paper and have read and approved the final manuscript.

Acknowledgements

This study was supported by a grant from the Windermere Foundation. We would also like to acknowledge the support of the Department of Education and Early Childhood Development (DEECD), Victorian Catholic Education Diocese, participating schools and students, and data collectors who made this research possible. Appreciation also goes to the Deakin Biostatistics Unit and University of Melbourne Statistical Consulting Unit for their statistical analyses advice. Barnett is supported by an Alfred Deakin Fellowship. Allender is supported by funding from an Australian National Health and Medical Research Council/ Australian National Heart Foundation Career Development Fellowship (APP1045836). Allender is a researcher on the US National Institutes of Health grant titled Systems Science to Guide Whole-of-Community Childhood Obesity Interventions (1RO1HL115485-01A1). Allender and Strugnell are researchers within a NHMRC Centre for Research Excellence in Obesity Policy and Interventions (1R01HL115485-01A1). Allender and Strugnell are researchers on the US National Institutes of Health Australian National Heart Foundation Career Development Fellowship and University of Melbourne Statistical Consulting Unit for their statistical analyses advice.

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References


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Chapter 6: Dietary behaviour and the primary to secondary school transition (Paper 2)

This chapter consists of an authorship statement for Paper 2, a longitudinal cohort study entitled: ‘Change of school in early adolescence and adverse obesity-related dietary behaviour: A longitudinal cohort study, Victoria, Australia, 2013–2014’, followed by the manuscript itself.

Paper 2 addresses the following research questions in relation to dietary behaviour:

RQ1. Do obesogenic behaviours change as children transition from primary to secondary school?

RQ2. Is there greater change of obesogenic behaviour for students who change their school environment?

RQ3. What are the differences between primary & secondary school contexts in relation to children’s PA & food environments?

The status of this paper is: Published
# AUTHORSHIP STATEMENT

1. Details of publication and executive author

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**Journal impact factor:** 2.12

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<tr>
<td>Jennifer Marks</td>
<td><a href="mailto:mjenn@deakin.edu.au">mjenn@deakin.edu.au</a></td>
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2. Inclusion of publication in a thesis

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3. HDR thesis author’s declaration

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<th>Name of HDR thesis author if different from above. (If the same, write “as above”)</th>
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<td>The TRANSFORM Study (Transition, School, Friends and Obesity Risk Models)</td>
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**If there are multiple authors, give a full description of HDR thesis author’s contribution to the publication (for example, how much did you contribute to the conception of the project, the design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.)**

**JM designed and executed the study (conception, methodological design, data collection and statistical analyses). JM drafted, revised and submitted the manuscript with critical revision from co-authors.**

**I declare that the above is an accurate description of my contribution to this paper, and the contributions of other authors are as described below.**

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4. Description of all author contributions

<table>
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<tr>
<th>Name and affiliation of author</th>
<th>Contribution(s) (for example, conception of the project, design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.)</th>
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<tr>
<td>Professor Steven Allender</td>
<td>Project conception, study design and critical revision of the manuscript</td>
</tr>
<tr>
<td>Principal supervisor</td>
<td>Study design and critical revision of the manuscript</td>
</tr>
<tr>
<td>Dr Lisa Barnett</td>
<td>Study design and critical revision of the manuscript</td>
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5. Author Declarations

I agree to be named as one of the authors of this work, and confirm:

i. that I have met the authorship criteria set out in the Deakin University Research Conduct Policy,

ii. that there are no other authors according to these criteria,

iii. that the description in Section 4 of my contribution(s) to this publication is accurate,

iv. that the data on which these findings are based are stored as set out in Section 7 below.

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I agree to be named as a non-author contributor to this work.

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* If an author or contributor is unavailable or otherwise unable to sign the statement of authorship, the Head of Academic Unit may sign on their behalf, noting the reason for their unavailability, provided there is no evidence to suggest that the person would object to being named as author.

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Introduction
Environments that facilitate energy-dense, nutrient-poor diets are associated with childhood obesity. We examined the effect of a change of school environment on the prevalence of obesity and related dietary behavior in early adolescence.

Methods
Fifteen schools in Victoria, Australia, were recruited at random from the bottom 2 strata of a 5-level socioeconomic scale. In 9 schools, students in grade 6 primary school transitioned to different schools for grade 7 secondary school, whereas in 6 schools, students remained in the same school from grade 6 to grade 7. Time 1 measures were collected from students (N = 245) in grade 6 (aged 11–13 y). Time 2 data were collected from 243 (99%) of the original cohort in grade 7. Data collected were dietary recall self-reported by students via questionnaire, measured height and weight of students, and aspects of the school food environment via school staff survey. Comparative and mixed model regression analyses were conducted.

Results
Of 243 students, 63% (n = 152) changed schools from time 1 to time 2, with no significant difference in weight status. Students who changed schools reported an increase in purchases of after-school snack food, greater sweetened beverage intake, fewer fruit- and-vegetable classroom breaks, and less encouragement for healthy eating compared with students who remained in the same school. School staff surveys showed that more primary than secondary schools had written healthy canteen policies and fewer days of canteen or food services operation.

Conclusion
A change of school environment has negative effects on children’s obesity-related dietary behavior. Consistent policy is needed across school types to support healthy eating in school environments.

Abstract
Introduction
Environments that facilitate access to energy-dense, nutrient-poor diets are major contributors to childhood overweight and obesity (1–3). Children living in socioeconomically disadvantaged areas are at greater risk of having poor diets, such as diets high in non-core foods (energy-dense low-nutrient foods such as sweets and snacks) and sugar-sweetened beverages and low in fruits and vegetables, because of differences in nutrition knowledge and food availability and accessibility (4). The school environment has a major influence on health and well-being during childhood and adolescence (5); school-specific (6) and system-wide interventions (7) are needed to promote healthy weight and long-term health benefits (1). Most school-based interventions target either the primary school or the secondary school (8), each associated with its own food environment, including type of food services, meal programs, canteen operations, food options, and pricing policies (9). Despite differences by school type, such as greater availability of snack foods and sugar-sweetened beverages in secondary schools (6), little is known empirically of the effect on eating behavior for students who change school during the transition from primary school to secondary school.
The transition from childhood to adolescence is recognized as a period in which healthy eating behaviors decline (10–12). Knowledge of how a change of school environment affects dietary behavior can help to inform healthy eating and healthy weight interventions in adolescence. The objective of this study was to longitudinally assess whether the prevalence of obesity and obesity-related dietary behavior in early adolescence is affected by a change from primary school to secondary school. A second aim was to compare school food environments by school type. We hypothesized a decline in healthy eating for students who changed schools. We further hypothesized differences in food environments between primary schools and secondary schools that may contribute to changes in dietary behavior.

Methods

Design and sample

This was a longitudinal study that followed a cohort of students in grade 6, their last year of primary school (aged 11–13 y) into grade 7, their first year of secondary school, with a change of location and type of school as the exposure of interest. Students were recruited across 2 types of schools (primary and secondary) and 2 types of school transitions. The first type of transition is described by a cohort of children who changed from a discrete primary school in grade 6 to a discrete secondary school in grade 7. The second type of transition is described by a comparison cohort of children who attended the same combined primary–secondary school (grades primary through 9 or primary through 12) for grade 6 and grade 7; henceforth, these schools will be called a P–12 school.

Ethics clearance was obtained from the Deakin University human research ethics committee, and permission to approach Victorian government schools was received from the school state authority. The sample and recruiting strategy is described elsewhere (13). In summary, grade 6 children were recruited from 9 primary and 6 P–12 state government (14) schools, randomly selected from the bottom 2 strata of a 5-level indexed socioeconomic scale (15). All grade 6 students at consenting schools were invited to participate; informed written parental consent for each student was required. For data collection in grade 7, an additional 31 secondary schools (where students who changed schools enrolled) were recruited. School staff members (school principal, canteen manager, and 3 teachers at each school) were invited to participate in a survey on the school food environment.

Parental consent was obtained for 40% (247/623) of invited students. The first data collection phase (time 1) was conducted from October through December 2013 with 245 participating students in their final term of primary school; 2 students were not available. Data collection was repeated (time 2) with 243 participants from time 1 (99% retention rate) 5 to 8 months later from April to June 2014, when participants were in term 2 of secondary school (the school year commences in late January with term 1).

Anthropometrics

On the day of the survey at both time 1 and time 2, height and weight were measured by trained researchers using a calibrated Charder HM200P height stadiometer (Charder Electronic Co, Ltd.) and a UC-321 weight scale (A&D Australasia Pty, Ltd.). Footwear and heavy outer clothing were removed before measurement according to standardized protocols (16). Height was recorded to the nearest 0.1 cm and weight to the nearest 0.1 kg. All measures were repeated, a third taken if the first 2 measures differed by at least 0.5 cm (height) or 0.5 kg (weight). Average measures were used for analysis. Body mass index (BMI), standardized scores, and weight status were defined using the World Health Organization’s age-specific BMI cut-points (17), a growth standard reference for children aged 5 to 19 years. Statistical calculations were conducted using the WHO reference 2007 module in Stata (StataCorp LP).

Questionnaires

Students completed behavioral questionnaires using questions from the Eat Well Be Active questionnaire (18), at time 1 and time 2 during a class period. Questions on usual fruit and vegetable intake asked students to indicate their usual quantity during the school day (at recess, lunch, and after school) and their total intake (number of servings) during a full day. Students were also asked to indicate usual school-day intake of 11 non-core food items and 3 sugar-sweetened beverages. The food items were 1) potato chips or a similar snack; 2) chocolate; 3) lollies (candy); 4) muesli or fruit bars; 5) savory biscuits; 6) sweet biscuits; 7) ice cream; 8) hot chips (french fries); 9) pies, pastries, or sausage rolls; 10) hot dogs; and 11) pizza. Students were also asked to specify “other” if applicable. The 3 sugar-sweetened beverages were cordials (a fruit-flavored nonalcoholic drink), fruit juices or drinks, and regular soft drinks. Each intake of an item was scored as 1. Non-core food items represent discretionary foods outside of the 5 main food groups (19) containing saturated fat, added salt, or sugars. In addition, we asked students how often they consumed potato chips, chocolate, lollies, or hot chips on a Likert scale of 1 to 5 (from 1 = don’t eat to 5 = >5 servings). A total non-core food score was calculated by summing scores for usual school-day intake items and daily derived Likert scores per item, according to the survey design (18). Similarly, a total score for sugar-sweetened beverages was derived by summing 1) usual school-day intake scores for each of the 3 sugar-sweetened beverages and 2) daily
Schools or not changing schools, mixed model regression analyses healthy weight vs overweight or obese) and between changing behavior by the binary outcomes for weight status (underweight or for continuous variables. To explore the differential effect on being-scored for analysis.

A survey on school environment, designed to assess schools as a setting for promoting healthy eating (20), with separate sections for school principals, teachers, and canteen managers, was completed by school staff. School principal surveys comprised 8 questions, including questions on school proximity to external food outlets, food policies, and food service operations. School teacher surveys comprised 8 questions on food policies and promotion of healthy eating. Teacher responses per school were averaged to 1 score per variable for each school. School canteen manager surveys comprised 11 food service questions, including questions on frequency of operation and types of foods provided.

Statistical analyses
A minimum sample size of 120 students (60 who changed schools, 60 who did not change schools) was needed to achieve 80% power for detecting a change in student behavior indicated by the 5-point Likert scale variables. To check for independence of schools before analysis, intraclass correlations were determined by student age, sex, and weight status and by each dependent variable at baseline to examine any school clustering effect. Proportions and means were calculated for student demographic variables with comparisons between students who changed schools and student who did not change schools. Mean values were calculated for student dietary behaviors and school food environment perceptions for both time 1 and time 2. Changes in weight status and dietary behavior from time 1 to time 2 and differences in student perceptions of school food environments between school types were assessed by using the exact McNemar test or the Bowker paired test of proportions for categorical variables or a paired t test of means for continuous variables. To explore the differential effect on behavior by the binary outcomes for weight status (underweight or healthy weight vs overweight or obese) and between changing schools or not changing schools, mixed model regression analyses for longitudinal data were conducted from time 1 to time 2 after adjusting for age and sex in change-of-school models and individual scores at baseline in all models. To adjust for school clustering, hierarchical models (level 1, individual; level 2, school) were fitted for a behavior where the intraclass correlation was greater than 0.20. This was applicable only for the variable “fruit and vegetable classroom break” (intraclass correlation = 0.43). Linear regression was used to model continuous variables, and Poisson regression (generating incidence rate ratios) was used to model count-dependent variables. No values were assumed or imputed for missing values. Data on health ratings of choices in canteens collected from 39 (16%) students at time 2 were excluded from analysis because of students not having an available canteen at time 1 to make a paired comparison. No significant difference in responses at time 2 were found between students who had a canteen option at time 1 and students who did not have a canteen option at time 1 ($\chi^2 = 2.04; P = .36$). Because of variations in staff response rates, statistical analyses of the school food environment were not conducted. Descriptive comparisons by school type were made instead to provide context of student exposure to different food environments. Significance was set at $P < .05$ (2-sided). All analyses were conducted using Stata 12.0 software (StataCorp LP).

Results
Of 243 students (98 boys, 145 girls) participating at both time points, 152 (63%) changed schools; 91 (37%) remained at the same P–12 school. At time 1, mean age was 12.2 years (12.3 y, boys; 12.2 y, girls; $P = .003$); at time 2, 12.7 years. No significant differences by ethnicity were found between boys and girls. Most (85%) were born in Australia. We found no significant differences for age, sex, or weight status by individual school at baseline, by school type at time 1 (between primary and P–12 schools), or by school type at time 2 (between secondary and P–12 schools).

Complete anthropometric data were collected for 238 of 243 (98%) participants at time 1 and time 2. Average prevalence of overweight/obesity was 35% in grade 6 (33% of students intending to change school, 39% of students not intending to change school; $P = .42$). In grade 7, average prevalence of overweight/obesity was 37% (34% of students who changed school, 42% of students who did not change school; $P = .23$).

The daily intake of non-core food items ($−1.2; 95% CI, −1.7 to −0.7; P < .001$) and sugar-sweetened beverages ($−0.3; 95% CI, −0.5 to −0.1; P < .001$) decreased after the transition to secondary school (Table 1). During the same period, the usual intake of school-day fruit ($−0.2; 95% CI, −0.4 to −0.1; P = .003$) and

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school-day vegetables (−0.2; 95% CI, −0.3 to −0.1; P < .001) also decreased, and perceptions of the school healthy eating environment declined.

School environment surveys were received from 45% (n = 20) of school principals, 2 from six P–12 schools, 7 from 9 primary schools, and 11 from 31 secondary schools (Table 2). Returned surveys from 48% (66 of 138) of school teachers represented 72% (33 of 46) of participating schools, comprising 100% (6 of 6) of P–12 schools, 89% (8 of 9) primary schools, and 61% (19 of 31) of secondary schools. Canteen manager surveys were received from 33% (13 of 39) schools with canteen or food services, representing 33% (2 of 6) of P–12 schools, 50% (2 of 4) primary schools, and 31% (9 of 29) of secondary schools.

Secondary school food environments were generally perceived as less conducive to promoting healthy eating than primary or P–12 schools (Table 2). Fewer secondary schools had healthy eating policies; they also had lower levels of compliance and awareness of their existence. Fewer teachers in secondary schools than in primary or P–12 schools perceived themselves as healthy eating role models. Among primary and secondary schools that operated a canteen or food service, no significant differences in type or pricing of foods by school type were found. All secondary school canteens operated each school day; primary schools averaged 2 days of operation per week.

Mixed model regression analysis (Table 3) identified more pronounced negative changes in some behaviors and perceptions among students who changed school than among students who remained in the same school. Participants who changed schools had a significantly smaller reduction in the mean score (−0.2) for sugar-sweetened beverage intake than students who did not change schools (−0.6) (P = .03 for difference). A change of schools was also associated with a decline in the frequency of fruit and vegetable classroom breaks (mean difference, −0.6; P = .01) and a reduction in school encouragement to eat healthily (mean difference −0.3; P = .03). Frequency of purchasing snack foods after school increased among students who changed schools and decreased among students who remained in the same school (mean difference 0.3; P = .03). No significant associations were found between weight status and dietary behavior.

Discussion

This study is the first to examine the effect of a change of school environment in early adolescence on obesity and obesity-related dietary behavior. Although no significant effect on BMI was found, obesity prevalence was high across the school transition. Overall, we found both positive and negative behavioral changes in all students transitioning from grade 6 to grade 7. We also found that participants who changed schools when transitioning from primary school to secondary school, compared with students who did not change schools, were exposed to less healthy eating environments and had poorer dietary behaviors.

Contrary to existing literature (10–12), intake of non-core food items and sugar-sweetened beverages decreased on average for all students during the study period. This decrease is not explained by seasonal influence (spring-summer [October–December] to autumn [April–June]); students who changed schools had less of a decline in intake of non-core food items and sugar-sweetened beverages, where a seasonal influence would be expected to affect the diet and intake of all students similarly. A Canadian study found a positive association between inadequate guidelines on healthy eating and the availability and intake of sugar-sweetened beverages at school (21). In contrast, an Australian study found that adolescent attitudes, peer modeling, and intentions were stronger predictors than the physical school environment of the consumption of sugar-sweetened beverages and snack foods (22).

Our findings suggest the change of school environment negatively affected eating behaviors. Further evidence is needed to determine the relative contribution of the change in school physical or school social environment on dietary behavior.

In line with trends among adolescents (23), school-day fruit and vegetable intake decreased overall for all students. Despite a drop overall in the frequency of fruit and vegetable classroom breaks from primary to secondary school, with a greater decrease in frequency for students who changed schools, a change of school did not significantly change level of intake. A recent systematic review supports these results, finding that individual preference and parental intake were more influential than the school food environment on fruit and vegetable intake among children and adolescents of low socioeconomic status (24). These findings may reflect already inadequate fruit and vegetable intake among adolescents (4,10–12), with the minimal amount consumed during the school day not having a significant impact on overall intake. To increase fruit and vegetable intake at school, efforts must take into account external influences as well as a review of the school food environment.

Local food environments in and around secondary schools can influence dietary intake among adolescents (6,25,26). Data on the proximity of the nearest food outlet did not explain an increase in snack food purchases by students who changed their school environment. A decline in healthy eating behavior among secondary school students might be explained by a combination of school factors, including lack of compliance or poor compliance with healthy food policies in canteens that operate daily, student rat-
ings of teachers as poorer role models of healthy eating, teacher perceptions of a lower proportion of teachers acting as healthy role models, and a larger decline in the frequency of fruit and vegetable classroom breaks at secondary schools than at primary schools. In Australia, national guidelines for implementing healthy canteens in schools are available, but conforming to guidelines is not mandatory (27), possibly explaining the differences in policy implementation and adherence by school type. Interventions that improve the school food environment can have positive effects on weight status, food choices, and eating behavior (28,29). Our findings also suggest that effective policies and interventions need to be implemented and practiced consistently by all types of schools as children move from one educational institution to another.

A major strength of this study was the high retention rate of longitudinal cohort participants, minimizing any potential bias from loss to follow-up. A further strength was the study design, which incorporated randomized and independent primary schools and P–12 schools at baseline. The study also had limitations. Pubertal status, a potential confounder in studies of obesity (30), was not known and hence was not adjusted for in the analysis. A further limitation was the use of student self-report for the data on dietary recall, which has the potential for underestimation and overestimation. However, validated instruments were used to analyze behavioral differences. Another limitation was the low staff response rates for the school environment surveys, preventing an analysis of associations between dietary behavior and environment. However, staff responses aligned with existing evidence, providing context to the different school environments to which students were exposed. Because of the study design by type of school and geographic location, results may not be generalizable to all school systems for students in early adolescence.

This study demonstrates that a change of school environment can negatively affect dietary behaviors that put adolescents at risk of obesity. Our findings have implications for policy, particularly policies on healthy eating and canteen operation in all levels of schooling. The disruptive effect on eating behavior of the transition from a primary school to a secondary school demonstrates the need for consistent messages to create environments that support healthy eating for the prevention of obesity and promotion of long-term health.

Acknowledgments

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References


### Table 1. Change in Student Dietary Behavior and School Perceptions From Time 1 (Grade 6) to Time 2 (Grade 7), Victoria, Australia, 2013–2014

<table>
<thead>
<tr>
<th>Variable (Potential Range for Each Variable)</th>
<th>No. of Responses</th>
<th>Time 1: Grade 6, Mean (SD) [95% CI]</th>
<th>Time 2: Grade 7, Mean (SD) [95% CI]</th>
<th>Time 1 to Time 2 Difference</th>
<th>Mean (SD) [95% CI]</th>
<th>p a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score for daily intake of non-core food (range, 0–33)</td>
<td>242</td>
<td>5.0 (4.2) [4.4 to 5.5]</td>
<td>3.8 (2.3) [3.5 to 4.1]</td>
<td>−1.2 (4.0) [−1.7 to −0.7]</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Score for daily intake of sugar-sweetened beverages (range, 0–11)</td>
<td>235</td>
<td>2.0 (1.5) [1.8 to 2.2]</td>
<td>1.7 (1.2) [1.5 to 1.8]</td>
<td>−0.3 (1.5) [−0.5 to −0.1]</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Usual daily frequency of fruit consumption (5-point scale of 1 = don’t eat to 5 = &gt;5 servings)</td>
<td>242</td>
<td>3.2 (0.8) [3.1 to 3.3]</td>
<td>3.1 (0.8) [3.0 to 3.2]</td>
<td>−0.1 (1.2) [−0.2 to 0]</td>
<td>.20</td>
<td></td>
</tr>
<tr>
<td>Usual school-day (recess, lunch, after school) fruit consumption (range, 0–6)</td>
<td>242</td>
<td>1.2 (1.1) [1.0 to 1.3]</td>
<td>0.9 (0.9) [0.8 to 1.1]</td>
<td>−0.2 (1.2) [−0.4 to −0.1]</td>
<td>.003</td>
<td></td>
</tr>
<tr>
<td>Usual daily frequency of vegetable consumption (5-point scale of 1 = don’t eat to 5 = &gt;5 servings)</td>
<td>243</td>
<td>3.2 (0.8) [3.1 to 3.4]</td>
<td>3.2 (0.8) [3.1 to 3.3]</td>
<td>−0.1 (0.8) [−0.2 to 0]</td>
<td>.22</td>
<td></td>
</tr>
<tr>
<td>Usual school-day (recess, lunch, after school) vegetable consumption (range, 0–3)</td>
<td>243</td>
<td>0.4 (0.7) [0.3 to 0.5]</td>
<td>0.3 (0.5) [0.2 to 0.3]</td>
<td>−0.2 (0.9) [−0.3 to −0.1]</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Frequency of fruit/vegetable classroom breaks (5-point scale from 1 = never to 5 = every day)</td>
<td>242</td>
<td>3.0 (1.8) [2.8 to 3.2]</td>
<td>1.5 (1.1) [1.4 to 1.6]</td>
<td>−1.5 (2.0) [−1.8 to −1.3]</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Rating of canteen choices (3-point scale from 1 = mostly unhealthy to 3 = mostly healthy)</td>
<td>204</td>
<td>1.7 (0.6) [1.7 to 1.8]</td>
<td>1.7 (0.6) [1.6 to 1.8]</td>
<td>−0.1 (0.7) [−0.2 to 0]</td>
<td>.14</td>
<td></td>
</tr>
<tr>
<td>School encourages healthy eating choices (4-point scale from 1 = not at all to 4 = a lot)</td>
<td>240</td>
<td>2.1 (0.9) [2.0 to 2.3]</td>
<td>1.7 (0.9) [1.6 to 1.9]</td>
<td>−0.4 (1.1) [−0.5 to −0.3]</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>Teachers as healthy eating role models (5-point scale from 1 = very poor to 5 = very good)</td>
<td>241</td>
<td>3.8 (1.0) [3.7 to 4.0]</td>
<td>3.6 (0.9) [3.5 to 3.8]</td>
<td>−0.2 (1.1) [−0.3 to −0.1]</td>
<td>.006</td>
<td></td>
</tr>
<tr>
<td>Frequency of buying snack food from shop after school (5-point scale from 1 = never to 5 = every day)</td>
<td>243</td>
<td>1.9 (1.0) [1.8 to 2.1]</td>
<td>1.9 (1.0) [1.8 to 2.1]</td>
<td>0 (1.1) [−0.1 to 0.2]</td>
<td>.86</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; SD, standard deviation.
a Determined by using paired t test of means for difference between time 1 and time 2.
### Table 2. School Food and Drink Environment by Type of School and Type of Staff Member Responding to Questionnairea, Victoria, Australia, 2013–2014

<table>
<thead>
<tr>
<th>Type of Administrator/Question</th>
<th>Combined Primary and Secondary Schools (n = 6)</th>
<th>Primary School (n = 9)</th>
<th>Secondary School (n = 31)</th>
</tr>
</thead>
<tbody>
<tr>
<td>School principals No. of principal responses</td>
<td>2</td>
<td>7</td>
<td>11</td>
</tr>
<tr>
<td>Proximity of nearest milk barb/fast food outlet (4-point scale from 1 [≤ 100 m] to 4 [&gt;1 km]), mean</td>
<td>3.0</td>
<td>2.4</td>
<td>2.7</td>
</tr>
<tr>
<td>Food service operating at the school in the last 12 months, % yes</td>
<td>100</td>
<td>86</td>
<td>91</td>
</tr>
<tr>
<td>Food service operated by external food company, % yes</td>
<td>0</td>
<td>33</td>
<td>64</td>
</tr>
<tr>
<td>Food service an important source of school funds, % yes</td>
<td>0</td>
<td>0</td>
<td>20</td>
</tr>
<tr>
<td>Food service exclusive contract with soft drink/other foods, % yes</td>
<td>0</td>
<td>0</td>
<td>25</td>
</tr>
<tr>
<td>Written food policy promoting nutrition and healthy eating, % yes</td>
<td>0</td>
<td>71</td>
<td>40</td>
</tr>
<tr>
<td>Students allowed to drink water in the classroom during class-time, % yes</td>
<td>100</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>School has a school vegetable garden, % yes</td>
<td>50</td>
<td>86</td>
<td>70</td>
</tr>
<tr>
<td>School teachersc No. of schools represented by teacher responses</td>
<td>6</td>
<td>8</td>
<td>19</td>
</tr>
<tr>
<td>No. of teacher responses</td>
<td>11</td>
<td>16</td>
<td>39</td>
</tr>
<tr>
<td>Existence of written school nutrition or healthy canteen policy (0 = no; 1 = yes), mean</td>
<td>0.3</td>
<td>0.7</td>
<td>0.2</td>
</tr>
<tr>
<td>School canteen provides foods high in nutritional value (1 = strongly disagree to 5 = strongly agree), mean</td>
<td>2.5</td>
<td>3.5</td>
<td>2.8</td>
</tr>
<tr>
<td>Proportion of teachers are aware of nutrition or healthy canteen policy (1 = very few to 5 = all), mean</td>
<td>2.4</td>
<td>4.1</td>
<td>2.5</td>
</tr>
<tr>
<td>Proportion of parents aware of nutrition or healthy canteen policy (1 = very few to 5 = all), mean</td>
<td>1.9</td>
<td>3.3</td>
<td>2.4</td>
</tr>
<tr>
<td>Nutrition or healthy canteen policy compliance in last 12 months (1 = very poor to 5 = very good), mean</td>
<td>2.8</td>
<td>4.4</td>
<td>3.6</td>
</tr>
<tr>
<td>Parental support for healthy eating in last 12 months (1 = very low to 5 = very high), mean</td>
<td>3.0</td>
<td>2.9</td>
<td>2.7</td>
</tr>
<tr>
<td>Proportion of teachers as good healthy eating role models (1 = very few to 5 = all), mean</td>
<td>4.5</td>
<td>4.3</td>
<td>3.5</td>
</tr>
<tr>
<td>Effectiveness of promoting healthy eating among students (1 = not effective to 4 = very effective), mean</td>
<td>2.8</td>
<td>2.9</td>
<td>2.7</td>
</tr>
<tr>
<td>Canteen managersd No. of canteen manager responses</td>
<td>2</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>No. of days per week school food service operated, mean</td>
<td>4.0</td>
<td>2.0</td>
<td>5.0</td>
</tr>
<tr>
<td>School food service open to students at recess, % yes</td>
<td>100</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

a School staff members (school principal, canteen manager, and 3 teachers at each school) were invited to participate in a survey on the school food environment.

b Small truck stop, corner store, or convenience store.

c Teacher responses per school were averaged to 1 score per variable for each school.

d Thirty-nine schools had canteen or food services: 6 P–12 schools, 4 primary schools, and 29 secondary schools.

(continued on next page)
### Table 2. School Food and Drink Environment by Type of School and Type of Staff Member Responding to Questionnaire*,
Victoria, Australia, 2013–2014

<table>
<thead>
<tr>
<th>Type of Administrator/Question</th>
<th>Combined Primary and Secondary Schools (n = 6)</th>
<th>Primary School (n = 9)</th>
<th>Secondary School (n = 31)</th>
</tr>
</thead>
<tbody>
<tr>
<td>School food service open to students at lunch time, % yes</td>
<td>50</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Fruit usually available from school food service, % yes</td>
<td>50</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>Vegetables/salad usually available from school food service, % yes</td>
<td>100</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Lollies/confectionary/chocolate usually available from school food service, % yes</td>
<td>0</td>
<td>0</td>
<td>33</td>
</tr>
<tr>
<td>Pies/sausage rolls/hot chips usually available from school food service, % yes</td>
<td>50</td>
<td>50</td>
<td>100</td>
</tr>
<tr>
<td>Crisps/chips usually available from school food service, % yes</td>
<td>50</td>
<td>0</td>
<td>89</td>
</tr>
<tr>
<td>Sugar-sweetened drinks usually available from school food service, % yes</td>
<td>50</td>
<td>0</td>
<td>56</td>
</tr>
<tr>
<td>Pricing policy to encourage sale of healthy foods at reduced cost, % yes</td>
<td>100</td>
<td>50</td>
<td>56</td>
</tr>
<tr>
<td>Food service routinely promotes healthy food choices, % yes</td>
<td>100</td>
<td>50</td>
<td>100</td>
</tr>
</tbody>
</table>

* School staff members (school principal, canteen manager, and 3 teachers at each school) were invited to participate in a survey on the school food environment.

b Small truck stop, corner store, or convenience store.

c Teacher responses per school were averaged to 1 score per variable for each school.

d Thirty-nine schools had canteen or food services: 6 P–12 schools, 4 primary schools, and 29 secondary schools.
Table 3. Effects on Student Dietary Behavior and School Perceptions From Time 1 (Grade 6) to Time 2 (Grade 7) by Change or No Change of School and Weight Status, Victoria, Australia, 2013–2014

<table>
<thead>
<tr>
<th>Dependent Variable</th>
<th>Change of School</th>
<th>Change of School vs No Change of School</th>
<th>Overweight/Obese vs Not Overweight</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Yes</td>
<td>No</td>
<td>Difference (95% CI)</td>
</tr>
<tr>
<td>Continuous</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Score for daily intake of non-core food (range, 0–33)</td>
<td>-1.0</td>
<td>-1.6</td>
<td>0.6 (-0.4 to 1.7)</td>
</tr>
<tr>
<td>Score for daily intake of sweetened beverages (range, 0–11)</td>
<td>-0.2</td>
<td>-0.6</td>
<td>0.4 (0 to 0.8)</td>
</tr>
<tr>
<td>Usual daily frequency of fruit consumption (5-point scale of 1 = don’t eat to 5 = &gt;5 servings)</td>
<td>-0.1</td>
<td>0</td>
<td>0 (-0.3 to 0.2)</td>
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<tr>
<td>Usual daily frequency of vegetable consumption (5-point scale of 1 = don’t eat to 5 = &gt;5 servings)</td>
<td>-0.1</td>
<td>0</td>
<td>-0.1 (-0.3 to 0.1)</td>
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<tr>
<td>Frequency of fruit and vegetable classroom breaks (5-point scale from 1 = never to 5 = every day)</td>
<td>-1.7</td>
<td>-1.1</td>
<td>-0.6 (-1.1 to 0.1)</td>
</tr>
<tr>
<td>Rating of canteen choices (3-point scale from 1= mostly unhealthy to 3 = mostly healthy)</td>
<td>-0.1</td>
<td>0</td>
<td>0 (-0.2 to 0.2)</td>
</tr>
<tr>
<td>School encourages healthy eating choices (4-point scale from 1 = not at all to 4 = a lot)</td>
<td>-0.5</td>
<td>-0.2</td>
<td>-0.3 (-0.6 to 0)</td>
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<tr>
<td>Teachers as healthy eating role models (5-point scale from 1 = very poor to 5 = very good)</td>
<td>-0.2</td>
<td>-0.2</td>
<td>0 (-0.3 to 0.3)</td>
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<tr>
<td>Frequency of buying snack food from shop after school (5-point scale from 1 = never to 5 = every day)</td>
<td>0.1</td>
<td>-0.2</td>
<td>0.3 (0 to 0.6)</td>
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<td>Categorical</td>
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<tr>
<td>Usual school-day (recess, lunch, after school) fruit consumption (range, 0–6)</td>
<td>-</td>
<td>-</td>
<td>IRR (95% CI)</td>
</tr>
<tr>
<td>Usual school-day (recess, lunch, after school) vegetable consumption (range, 0–3)</td>
<td>-</td>
<td>-</td>
<td>0.9 (0.6–1.2)</td>
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Abbreviation: —, does not apply; CI, confidence interval, IRR, incidence rate ratio.

\(a\) Change of school models adjusted for age and sex.

\(b\) \(P\) value for test value of linear regression interaction effects.

\(c\) Multilevel models account for clustering at the school level.

\(d\) \(P\) value for test value of Poisson regression interaction effects.

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Chapter 7: Physical activity, sedentary behaviour and friendship networks (Paper 3)

This chapter consists of an authorship statement for Paper 3, a cross sectional study with primary school students entitled: ‘Friendship network characteristics are associated with physical activity and sedentary behaviour in late childhood’, followed by the manuscript itself.

Paper 3 addresses the first phase of the following research question:
RQ4. Are friendship networks associated with a change in obesogenic behaviour?

The status of this paper is: Published
# AUTHORSHIP STATEMENT

1. Details of publication and executive author

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<td>Name of executive author</td>
<td>Jennifer Marks</td>
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3. HDR thesis author’s declaration

| Name of HDR thesis author if different from above. (If the same, write “as above”) | As above |
| School/Institute/Division if based at Deakin | The TRANSFORM Study (Transition, School, Friends and Obesity Risk Models) |
| Thesis title | If there are multiple authors, give a full description of HDR thesis author’s contribution to the publication (for example, how much did you contribute to the conception of the project, the design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.) |
| JM designed and executed the study (conception, methodological design, data collection and statistical analyses). JM drafted, revised and submitted the manuscript with critical revision from co-authors. |

I declare that the above is an accurate description of my contribution to this paper, and the contributions of other authors are as described below.

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4. Description of all author contributions

| Name and affiliation of author | Contribution(s) (for example, conception of the project, design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.) |
| Professor Steven Allender Principal supervisor | Project conception, study design and critical revision of the manuscript |
| Dr Kayla de la Haye Associate supervisor | Study design, analytical advice and critical revision of the manuscript |
| Dr Lisa Barnett Associate supervisor | Study design and critical revision of the manuscript |
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I agree to be named as one of the authors of this work, and confirm:

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<td>Dr Kayla de la Haye</td>
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I agree to be named as a non-author contributor to this work.

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* If an author or contributor is unavailable or otherwise unable to sign the statement of authorship, the Head of Academic Unit may sign on their behalf, noting the reason for their unavailability, provided there is no evidence to suggest that the person would object to being named as author.

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Friendship Network Characteristics Are Associated with Physical Activity and Sedentary Behavior in Early Adolescence

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Abstract

Introduction

There is limited understanding of the association between peer social networks and physical activity (PA), sedentary and screen-related behaviors. This study reports on associations between personal network characteristics and these important health behaviors for early adolescents.

Methods

Participants were 310 students, aged 11–13 years, from fifteen randomly selected Victorian primary schools (43% response rate). PA and sedentary behaviors were collected via accelerometer and self-report questionnaire, and anthropometric measures via trained researchers. Participants nominated up to fifteen friends, and described the frequency of interaction and perceived activity intensity of these friends. Personal network predictors were examined using regression modelling for PA and sedentary/screen behavior.

Results

Perceived activity levels of friends, and friendships with very frequent interaction were associated with outside-of-school PA and/or sedentary/screen time. Differences according to sex were also observed in the association between network characteristics and PA and sedentary time. A higher number of friends and greater proportion of same sex friends were associated with boys engaging in more moderate-to-vigorous PA outside of school hours. PA intensity during school-day breaks was positively associated with having a greater proportion of friends who played sports for girls, and a greater proportion of male friends for boys.

Conclusion

Friendship network characteristics are associated with PA and sedentary/screen time in late childhood/early adolescence, and these associations differ by sex. The positive
influence of very active peers may be a promising avenue to strengthen traditional interventions for the promotion of PA and reduction in screen time.

Introduction

Few children meet recommended physical activity (PA) guidelines for optimal health benefits [1], and PA declines over childhood [2–5]. Sedentary behavior, which is often inversely related to PA but nonetheless qualitatively distinct, is also high and increasingly prevalent among children, particularly computer/TV screen time [6]. Both inadequate PA and excessive sedentary leisure time increase the risk of overweight, obesity and associated health risks in childhood [7, 8]. Further, these trends developed in childhood and adolescence track into adulthood [9, 10].

Emerging evidence exploring friendship influence on PA and sedentary behavior has identified a relationship between friends or broader peer groups and PA in late childhood/early adolescence [11, 12]. Peers are an integral, adaptive, and important influence on development and behavior throughout childhood [13]. Social influence theories suggest health-related behavior is influenced by a person’s social context through various mechanisms such as peer modelling, imitation, and social learning [14]. Normative behavior (or perceptions thereof) is a further mechanism of social influence, whereby youth are motivated to adopt the typical behaviors of their peers to gain or retain group acceptance [15]. Social influence is also known to vary based on the depth of a relationship, with close friends often having more influence on an individual’s behavior than the broader peer group [16, 17]. Throughout childhood, a large proportion of these close friendships develop and flourish within the school environment. Social influence processes among friends (particularly close school friends) give rise to behavioral similarities among peers, although it is important to note that similarity may also be due to homophily; the tendency for youth to select and befriend others who are already similar to themselves in some way [18, 19]. The complex social mechanisms driving behavior in childhood and adolescence are important to understand [20]. This is particularly true of social contexts where children’s PA and sedentary behaviors take shape, to help inform PA interventions for altering or utilizing valuable social contingencies [21]. It is especially valuable to understand the role of peers in shaping these behaviors both at a time when peers become increasingly important referents for behavior from late childhood [22], and when PA is in decline.

Social network data captures a holistic perspective of social systems, such as how characteristics of the child and their social network partners collectively explain activity/sedentary behavior. Through examination of social network structure, composition, and social position, social network analyses explore relationships between an individual and particular network characteristics [23]. Evidence to-date demonstrates that children’s PA behavior is similar to that of their friends [24–26], particularly close/best friends [27–30], with peer influence on PA behavior generally stronger for boys than girls [12]. Research of friendship influence on sedentary behavior in late childhood/early adolescence is limited [11, 12], with findings of no association (age 12–18 years) [24], or differing by sex and/or network characteristic [28, 30]. Girls have been shown to have similar screen behavior within their friendship networks, while among males the evidence is mixed [28, 30]. Studies of peer influence on PA/screen behavior typically have not examined the strength of friendships beyond the distinction of either best/close friends or the broader peer group. For instance, close friends who see one another very frequently might conceivably influence each other’s behavior more than friends who interact occasionally.
Research on friendship associations with behavior is emerging, yet the complex characteristics of these relationships, and how they may differentially be associated with youth PA, is not well understood [11, 12, 20, 31]. Current evidence demonstrating relationships between friendships and PA has been conducted in varying social contexts and in different stages of childhood and adolescence [24, 26–30, 32–34]. More evidence on friends in relation to sedentary behavior is also needed. Further exploration of types of associations between networks and these activity behaviors is needed to advance our knowledge of mechanisms that impact youth PA, and to inform evidence-based health promotion intervention. The current study extends existing research by considering how these relationships hold when we look at more complex definitions of friendship, and more specific type of behavior.

The aim of this study was to explore cross-sectional associations between PA, sedentary behavior and friendship in late childhood/early adolescence. Being a cross-sectional study, proposed mechanisms are based on theoretical perspectives and evidence to-date, but cannot be empirically tested. We explore PA and sedentary behavior associations with the size of friendship groups, frequency of interaction (inside and outside of school), and perceptions of others. Specifically, this was achieved by identifying nuanced personal friendship network characteristics (including number, frequency of interaction, and perceived activity level of friends), and through exploration of how these factors were associated with an individuals’ level of PA and sedentary behavior from late childhood. The secondary aim was to explore whether these associations differ according to sex. The investigation was based on: social norms theory where behavior is adopted of the broader group for peer acceptance; social facilitation theory where the presence of others affects individual behavior [35]; and social modelling theory where individuals imitate valued peers [13, 14].

Methods
Design and sample
Participants were 310 students (age 11–13 years) from 15 schools in Victoria, Australia. The sampling frame comprised all Victorian state government primary schools [36] stratified by a five-level indexed socio-economic scale. Schools were randomly selected from the bottom two socio-economic strata and invited to participate. Fifteen of twenty-seven schools approached (56%) provided written consent. The study was targeted towards year 6 students but one school region wished to involve more students, hence all students within year 6 at all schools and in year 5 at six schools, were invited to participate. Years 5 and 6 within these Australian schools represent the last years of primary schooling before the transition to secondary school commencing in year 7. Written parental consent was received for 43% (313/736) of invited students. The study was conducted in the 2013 final school term (Oct-Dec), three consenting students not available. Participation comprised completing a self-report behavioral and social network questionnaire, having anthropometric measurements taken, and wearing an accelerometer over a one week period. Methods other than the social network questionnaire have been described in detail elsewhere [37], and are outlined below.

This study was reviewed and approved by the Deakin University Human Research Ethics Committee (2013–093) and permission to approach schools was received from the Department of Education and Early Childhood Development (2013_001992) state school authority. Written informed parental consent was required for each study participant. Informed verbal consent from each participant was also obtained at the time of data collection. Students were assured they were free to withdraw or choose not to participate at any stage without any consequence. Strict confidentiality and documentation was maintained throughout the process of data collection and analysis.
Self-report behavior

Self-report PA 5-point Likert scale and usual screen-time based questions [38] were collapsed into binary or categorical variables for analysis as follows. Recess and lunch PA intensity: 0) Low (sitting/walking); 1) Moderate-to-vigorous PA (MVPA) (playing/running). Physical education (PE) MVPA frequency: 0) Never/sometimes; 1) Quite often/always. Walking/cycling to/from school weekly frequency: 1) 0 times; 2) 1–5 times; and 3) 6–10 times. Self-report weekend MVPA: 0) <60 min/day; 1) ≥60 min/day. After-school MVPA: 0) <30 min/day; 1) ≥30 min/day, as a proxy for meeting/not meeting daily recommendations, derived using the after-school period from 3:30-6pm of 2.5 hours [39] as 50% of five hours of potential active time across the school day (0.25hr active transport to school, 1.25hrs recess and lunch periods, 1hr PE, 2.5hrs after-school). Average daily screen-time (weekdays and weekends) were categorized as either meeting or not meeting ≤2hrs/day guideline. Screen-time was capped at a maximum of 8 hours per day [40].

Personal friendship networks

Participants listed the full names, school-year level, and sex of up to fifteen friends they “hang around with the most”, and whether the friend attends their school. For each friend, they also reported on the times/settings in which they “hang around” (recess, lunch, after school, and/or weekends), used to compute a summary frequency of interaction score (from 0–4). “Very frequent interaction” (score of 3–4) was defined to denote friendships that involve interactions both inside and outside of school. Participants also indicated whether they usually played sport with each friend ‘more than once a week’, and their perception of how active their friend was [1) not very active (doesn’t do sport or exercise very often at all); 2) sometimes active (once or twice a week); 3) very active (most days)].

Summary network variables were computed to represent the total number of nominated friends (network out-degree), and percentages of total nominated friends with the following characteristics: same sex as participant; same school-year level; not attending the same school; play sport with; perceived PA level; and interaction time/setting (recess, lunch, afterschool, weekends). Multiplex variables, summarizing multiple dimensions of a participant’s social network characteristics, were derived for the proportion of friends: (1) with very frequent interaction, (2) with very frequent interaction who were also “very active”, and (3) at recess, lunch, after-school or weekends who were very active. Distributions of these network characteristics, reported as medians, were often heavily skewed towards 0% or 100%. Due to the limited data variability in some network characteristics in this sample, many of which are typical of this age group (e.g. tendencies to have predominantly same sex friends), some variables were recoded as binary. In instances where ≥75% participants reported 0% of a characteristic (% not same school’, ‘% very frequent interaction’, ‘% very active friends of frequent interaction’, ‘% very active after-school friends’, ‘% very active weekend friends’, ‘% sometimes active’ and ‘% not very active’), the network variable was recoded as ‘0’ meaning 0% of the network or ‘1’ meaning a percentage greater than a null value. Where ≥75% of participants reported networks with 100% of a particular characteristic (’% same sex’ and ‘% in same year level’), the network variable was recoded as ‘1’ meaning 100% of the network or ‘0’ meaning a percentage less than 100% of the network. All other network characteristics that were represented as percentages showed greater variability, namely ‘% play sport with’ and ‘% very active’, and so were recoded into an equal interval 10-point scale, and rounded to whole numbers.

Anthropometrics

Due to the relationship between BMI and the behaviors of interest, and evidence of an effect between BMI and friendship selection and influence [41], weight status was calculated and
controlled for to accurately identify network associations with PA and sedentary behavior.

Height and weight were measured using calibrated Charder HM200P height stadiometers and A&D UC-321 weight scales according to standardized protocols [42]. Average measures were used for analysis. Body Mass Index (BMI; weight in kg/(height in m)²) and standardized scores were calculated using the WHO reference 2007 Stata module. Weight status was defined using WHO age-specific BMI cut-offs, and categorized as either "under/normal weight" (BMI ≤ 1 standard deviation (SD)) or "overweight/obese" (BMI > 1 SD) [43].

**Accelerometry**

Objective PA data was collected via ActiGraph GT1M accelerometer (ActiGraph LLC, Pensacola, US) [44], recorded at 15 second epochs and analyzed using ActiLife 6 software. Minimum wear time was defined as 480 minutes over any three 8 hour days, non-wear time as >60 minutes of consecutive zero counts with a 2-minute tolerance [45, 46]. Intensity cut points were defined as: sedentary (<1.5 metabolic equivalents (METs); ≤ 100 counts/min); light PA (≥ 1.5 to <4 METs); and MVPA (≥ 4 METs) [47]. MVPA was further categorized as "<60 min/day" and "≥60 min/day".

**Statistical analyses**

Demographic, behavior and personal network descriptive analyses were conducted by gender from the compiled dataset (S1 Dataset). To account for clustering (nesting) of individuals, multilevel regression models were fit using a two-level approach at the school and individual level. To test specific personal network characteristic associations (out-degree, % very frequent interaction, % very active and % same sex) with PA/sedentary behavior, each variable was initially included within regression models. The network variable '% play sport with' was also tested in each model, as an important characteristic identified within other network studies [12]. Where two or more variables were highly correlated (r > 0.6), (e.g. multiplex variables and their originally derived variable), only one variable was included within the same model. Non-statistically significant exploratory variables were dropped from models if their effect size was small, or had little effect on the model. These included the variables: % not same school, % in same year level, and % very active friends of frequent interaction. Little variation at the school level from initial models were identified, however final multilevel models were fit to account for any potential clustering effect. Final models were also adjusted for age and categorical weight status, with separate analyses by sex. Objective PA models were also adjusted for accelerometer wear time. Linear, logistic and Poisson regression were used to model continuous, dichotomous and count outcome variables respectively. Final regression models are shown separately for males and females for each dependent variable. All exploratory variables were retained within each model unless their inclusion resulted in non-statistical significance. Due to the low response rate within some schools, we focus on personal network characteristics and not complete network characteristics (e.g. participant position within the school friendship network), as the latter approach requires complete or near-complete response rates. All analyses were conducted in 2015 using Stata 12.0 software (StataCorp LP, College Station, US).

**Results**

**Descriptive characteristics**

Descriptive statistics are provided in Table 1. Mean age of participants was 12.1 years: 129 male (42%); 181 (58%) female. Thirty-eight percent of participants (44% male; 34% female) were overweight or obese. Accelerometer derived measures and most self-report behaviors show...
Table 1. Participant characteristics: demographic and behavior.

| Demographic                  | All (n = 310) | Male (n = 129) | Female (n = 181) | p>|     |
|------------------------------|---------------|----------------|------------------|-----|
| Age, years                   |               |                |                  |     |
| Mean (SD)                    | 12.1 (0.5)    | 12.1 (0.6)     | 12.0 (0.5)       | 0.12|
| School level                 |               |                |                  |     |
| Year 5, n (%)                | 65 (21)       | 31 (24)        | 34 (19)          | 0.26|
| Year 6, n (%)                | 245 (79)      | 98 (76)        | 147 (81)         |     |
| Weight status                |               |                |                  |     |
| Under/normal weight, n (%)   | 190 (62)      | 72 (56)        | 118 (66)         | 0.09|
| Overweight/obese, n (%)      | 117 (38)      | 56 (44)        | 61 (34)          |     |
| Missing, n                   | 3             | 1              | 2                |     |
| Behavior: Physical activity  |               |                |                  |     |
| MVPA by recommendation¹     |               |                |                  | <0.01|
| < 60 min/day, n (%)          | 184 (73)      | 58 (57)        | 126 (83)         |     |
| ≥ 60 min/day, n (%)          | 69 (27)       | 43 (43)        | 26 (17)          |     |
| Missing, n                   | 57            | 28             | 29               |     |
| Average daily (min) MVPA¹    | Mean (SD)     | 51 (19)        | 58 (20)          | <0.01|
| Average daily (min) light PA¹| Mean (SD)     | 221 (42)       | 229 (44)         | 0.02|
| MVPA after school²           |               |                |                  |     |
| < 30 min/day, n (%)          | 94 (31)       | 38 (30)        | 56 (32)          | 0.73|
| ≥ 30 min/day, n (%)          | 209 (69)      | 89 (70)        | 120 (68)         |     |
| Missing, n                   | 7             | 2              | 5                |     |
| MVPA on weekends²            |               |                |                  | <0.01|
| < 60 min/day, n (%)          | 138 (45)      | 45 (35)        | 93 (52)          |     |
| ≥ 60 min/day, n (%)          | 171 (55)      | 84 (65)        | 87 (48)          |     |
| Missing, n                   | 1             | 0              | 1                |     |
| PE very active frequency²    |               |                |                  | 0.06|
| Never or sometimes, n (%)    | 72 (23)       | 23 (18)        | 49 (27)          |     |
| Quite often or always, n (%) | 237 (77)      | 105 (82)       | 132 (73)         |     |
| Missing, n                   | 1             | 1              | 0                |     |
| Activity level at recess²    |               |                |                  | <0.01|
| Low (sitting, walking), n (%)| 144 (47)      | 40 (32)        | 104 (58)         |     |
| Moderate to vigorous, n (%)  | 162 (53)      | 87 (69)        | 75 (42)          |     |
| Missing, n                   | 4             | 2              | 2                |     |
| Activity level at lunch²     |               |                |                  | <0.01|
| Low (sitting, walking), n (%)| 124 (41)      | 32 (25)        | 92 (52)          |     |
| Moderate to vigorous, n (%)  | 182 (59)      | 96 (75)        | 86 (48)          |     |
| Missing, n                   | 4             | 1              | 3                |     |
| Walk to/from school²         |               |                |                  | 0.87|
| 0 times/week, n (%)          | 155 (50)      | 65 (50)        | 90 (50)          |     |
| 1–5 times/week, n (%)        | 98 (32)       | 42 (33)        | 56 (31)          |     |
| 6–10 times/week, n (%)       | 57 (18)       | 22 (17)        | 35 (19)          |     |
| Cycle to/from school²        |               |                |                  | 0.09|
| 0 times/week, n (%)          | 230 (74)      | 92 (71)        | 138 (76)         |     |
| 1–5 times/week, n (%)        | 58 (19)       | 23 (18)        | 35 (19)          |     |

(Continued)
males to be more physically active than females. Proportionately more males engaged in higher levels of screen time on weekdays compared to females. No significant differences were found by sex for self-report MVPA after school, PE active frequency, walking and cycling to school, or weekend recreational screen time.

Personal friendship network descriptive statistics are given in Table 2. Mean network out-degree was 6.1 (males: 5.5; females: 6.5; P < 0.05). Almost all nominated friends were of the same sex as the participant, with very few not from the same school. Recess and lunch were times of high interaction with nominated friends. Participants had few (median = 13%) ‘friends with very frequent interaction’ (friends both inside and outside of school). Participants rated at least half (median: males 75%; females 50%) of their social networks as ‘very active’, while very few (median = 0%) were perceived as ‘not very active’. Compared to females, males had a significantly higher average percentage of friends they played sport with, spent recess and lunch times with, and who were perceived as very active. Females reported a greater proportion of friends who were perceived as being ‘sometimes active’ compared to males (median: females 33%; males 13%)

**Physical activity**

Regression models are shown separately for each dependent PA variable and by gender in Table 3. Personal network characteristics that were statistically significant predictors of an individual’s PA generally differed for males and females.
Friendship number and frequency of interaction. For males, as out-degree friendship nominations increased, the odds of achieving at least 30 min/day MVPA (self-report) after-school (OR = 1.33; 95% CI = 1.09, 1.62) or 60 min/day on weekends (OR = 1.38; 95% CI = 1.15, 1.66) increased. Having friendships that entailed frequent interaction was also positively associated with time spent engaging in MVPA (self-report) on weekends for males (OR = 2.92; 95% CI = 1.24, 6.86) and females (OR = 2.36; 95% CI = 1.24, 4.49), and after-school for males only (OR = 3.01; 95% CI = 1.13, 8.01).

More active friends. For females, engaging in at least 60 min/day MVPA (self-report) on weekends was positively associated with the proportion of their friends perceived as being ‘very active’ (OR = 1.14; 95% CI = 1.03, 1.26). Females were also more likely to engage in MVPA (self-report) at recess (OR = 1.11; 95% CI = 1.0, 1.22) and lunch (OR = 1.14; 95% CI = 1.03, 1.26), and for at least 30 min/day after-school (OR = 1.15; 95% CI = 1.03, 1.28) if they had a higher proportion of friends they usually ‘played sport with’. For males, having a higher proportion of after-school friends who were also very active was associated with an increase in objectively measured MVPA (9 min/day; 95% CI = 1.71, 17.03) and a higher frequency of cycling to/from school (OR = 3.66; 95% CI = 1.54, 8.71).

Friends of the same sex. For males only, having a higher proportion of male friends increased the likelihood of engaging in MVPA (self-report) at recess (OR = 8.22; 95% CI = 1.93, 34.76).
CI = 2.29, 29.54) and lunch (OR = 4.71; 95% CI = 1.45, 15.30), and for at least 60 min/day on weekends (OR = 4.43; 95% CI = 1.53, 12.80).

No association. Physical activity outcomes that were not significantly predicted by personal network characteristics, after adjusting for age and weight status, included: (1) PE activity

### Table 3. Regression models for personal network characteristic predictors of PA for males and females.

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<thead>
<tr>
<th></th>
<th>Males MVPA min/day (accelerometer)</th>
<th>After school MVPA SR (≥ 30 min/day)</th>
<th>Weekend MVPA SR (≥ 60 min/day)</th>
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<tr>
<td></td>
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<td>OR 95% CI p OR 95% CI p OR 95% CI p</td>
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<tr>
<td>% of same sex friends1</td>
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<tr>
<td>% usually play sport with2</td>
<td>0.29 -0.85, 1.43 0.62 0.96 0.82, 1.13 0.60 0.97 0.85, 1.11 0.70</td>
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<tr>
<td>% very active2</td>
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<tr>
<td>% very frequent interaction 3,4</td>
<td>CV 3.01 1.13, 8.01 0.03 2.92 1.24, 6.86 0.01</td>
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</tr>
<tr>
<td>% very active after school friends3</td>
<td>9.37 1.71, 17.03 0.02 CV CV</td>
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<td>% usually play sport with2</td>
<td>1.08 0.97, 1.21 0.18 1.14 1.03, 1.26 0.01</td>
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<tr>
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<th>Lunch time MVPA (SR rating)</th>
<th>Cycle to/from school (no. of times)</th>
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<td>Total friends (outdegree)</td>
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<td>% of same sex friends1</td>
<td>8.22 2.29, 29.54 &lt;0.01 4.71 1.45, 15.30 0.01 2.17 0.66, 7.10 0.20</td>
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<tr>
<td>% usually play sport with2</td>
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<tr>
<td>% very active2</td>
<td>1.09 0.94, 1.27 0.23 1.07 0.92, 1.24 0.37 NS</td>
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<tr>
<td>% very frequent interaction 3,4</td>
<td>2.14 0.79, 5.82 0.14 2.65 0.95, 7.37 0.06 NS</td>
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<tr>
<td>% very active after school friends3</td>
<td>CV CV</td>
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<tr>
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<tr>
<td>% very active2</td>
<td>1.06 0.95, 1.17 0.28 1.06 0.95, 1.18 0.29</td>
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<tr>
<td>% very frequent interaction 3,4</td>
<td>NS 1.03 0.52, 2.04 0.93</td>
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</table>

OR, odds ratio; 95% CI, 95% confidence interval; MVPA, moderate to vigorous physical activity; PA, physical activity; SR, self-report CV, correlated with other variable within model; NS, model not significant if variable included

All models controlled for individual level (age and weight status) and school level covariates. Objective measured PA models controlled for accelerometer wear time.

p, test value, boldface indicates statistical significance (p<0.05)

1. Binary variable recoded as either 100% or less than 100%;
2. 10-point scale variable;
3. Binary variable coded as either 0% or greater than 0%;
4. Frequency of interaction at least 3 of 4 from recess, lunch, after school or weekends

doi:10.1371/journal.pone.0145344.t003
intensity, and (2) light PA (objective) for males and females; and (3) objective MVPA and (4) walking/cycling to/from school for females.

Sedentary behavior

For females, spending more than two hours/day in recreational screen time on weekends was inversely associated with the proportion of having 'very active' friends (OR = 0.87; 95% CI = 0.78, 0.96), as presented in Table 4. For males, a higher proportion of friends perceived as 'sometimes active' was predictive of more sedentary time (24 min/day).

No network characteristics were found as predictors of: (1) weekday recreational screen time (all); (2) weekend recreational screen time (males); or (3) sedentary time (females).

Discussion

Type and intensity of friendship, and the time and context of interaction with friends were associated with different behaviors, many of these differing by gender. Time spent engaging in PA was positively associated with having higher: numbers of friends; proportion of friends with frequent interaction; and proportion of friends perceived as being very active. An inverse relationship between participant screen time and the proportion of their friends that were very active friends was also found. A unique aspect of this study was the exploration of relational nuances of where and when friends interact, offering a temporal and contextual perspective of which relationships matter to PA and sedentary behavior from late childhood.

Previous research suggests that close friends who are also active provide youth with opportunities for PA engagement and behavior modelling [27], where close friends’ PA behaviors are adopted and become increasingly similar over time [29]. Contrary to expected [27], we did not find increased frequency of interaction among friends, likely indicative of friendship intensity/‘closeness’, to be more prominently associated with overall PA than other friendship network predictors. Having very active close (of frequent interaction) friends was not an important PA predictor over and above having very active friends. In their study of late childhood, Jago et al. [27] found best friends MVPA to be predictive of participant MVPA, whilst de la Haye et al. [28] found the broader close friend network was associated with PA engagement. Similarly, the current study found MVPA associations among the broader identified friendship group, and close friends as further differentiated within the network (high frequency of interaction), but unlike Jago et al.[27] and de la Haye et al.[28], these associations were not dependent upon MVPA of the best/close friend. It is possible that MVPA of best/close friends were similar within the current study, however other network characteristics such as out-degree and gender were also shown to be predictive of individual MVPA. Together these studies of different friendship characteristics demonstrate the potential for friends to influence and reinforce normative PA behavior. Results also suggest that whilst close friends are important, social influence from friends through modelling or adopting normative behaviors is no more prominent among close friends than the broader friendship group. This implies that interventions, rather than focusing on close friend behavior modelling, should consider targeting whole friendship groups, as it is the larger group normative behaviors that are important. Efforts to promote PA should also consider how to provide PA opportunities for those who have few close friends, or who are socially marginalized from their peers.

Few associations with objectively measured MVPA were evident within the current study. Despite this, using nuanced personal network characteristics we were able to tease out associations with PA at various times of the day/week using self-reported measures. It could be that participants have similar biases for perceptions of their own PA and that of their friends, inflating the association between these variables. However results are consistent with evidence of
positive associations between friends and objectively derived MVPA outside of school hours in childhood [27, 33], identifying potential areas to target for increasing overall MVPA throughout the week day.

Although having more friends had no impact on average daily MVPA, the likelihood that boys spent ≥ 60 minutes/day in MVPA on weekends, and ≥ 30 minutes after school, increased with more friends. Previous research has identified the size of children/adolescents’ friendship groups [28] and the proportion of friends they play sports with [24] to be positively associated with PA. Together these findings suggest that having more friends increases opportunity for PA engagement (likewise, social isolation/less friends reduces opportunity) [48] particularly outside of school-hours, such as team-based structured sporting activity.

There is evidence that gender of friends is an important factor that may impact peer influence on adolescent PA, with friend similarity on PA level evident among same-sex friends [26, 28, 30]. Within the current study, having female friends was not associated with females engaging in MVPA, but for males, having more male friends was significant for MVPA. In contrast, a large US based study with adolescents (average age 14 years) found MVPA in females to be positively associated with their male and female friends, and MVPA in males to be positively associated with their female (but not male) friends [26]. Although different in sample size and geographic region, both studies had higher PA reported by males, similar levels of overweight status in boys and girls, and a similar number of friends nominated by participants. The main difference was the friendship characteristic tested. Sirard et al. [26] found MVPA time was positively predicted by their friends MVPA, dependent upon the gender of the friend, as important dyad-level characteristics for influencing PA. The current study, which does not focus on PA homophily and gender between friends, provides additional insight into the role of gender and MVPA within relationships that have varying levels of intensity and interaction contexts, by

<table>
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<th>Table 4. Regression models for personal network characteristic predictors of sedentary (males) and weekend-screen time (females).</th>
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<td><strong>Males</strong></td>
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<td>-----------------------------------------------</td>
</tr>
<tr>
<td>Total friends (outdegree)</td>
</tr>
<tr>
<td>% of same sex friends$^1$</td>
</tr>
<tr>
<td>% sometimes active$^2$</td>
</tr>
<tr>
<td>% very frequent interaction $^{2,3}$</td>
</tr>
<tr>
<td><strong>Females</strong></td>
</tr>
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<td></td>
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<tr>
<td>-----------------------------------------------</td>
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<tr>
<td>Total friends (outdegree)</td>
</tr>
<tr>
<td>% very active$^4$</td>
</tr>
<tr>
<td>% very frequent interaction $^{2,3}$</td>
</tr>
</tbody>
</table>

All models controlled for individual level (age and weight status) and school level covariates. Objective measured sedentary time models controlled for accelerometer wear time.

OR, odds ratio; 95% CI, 95% confidence interval

$^1$ Binary variable recoded as either 100% or less than 100%;
$^2$ Binary variable coded as either 0% or greater than 0%;
$^3$ Frequency of interaction at least 3 of 4 from recess, lunch, after school or weekends;
$^4$ 10-point scale variable

doi:10.1371/journal.pone.0145344.t004
examining how characteristics of social networks as a whole, including gender composition and other factors, are relevant to adolescent PA. Together, these results demonstrate the importance of considering both gender and the context of friendship groups when targeting increased PA in early adolescence.

In the current study, playing sport with friends was a significant factor for girls (but not boys) engaging in more MVPA time after school, and increasing PA intensity at school recess and lunch times. In contrast, a recent study found no association between PA and girls (slightly younger, aged 10–11) playing sport with friends [27]. It could be that early adolescence is an important time in the development of friendship influence on individual behavior, and suggests that promoting structured activity may be an effective strategy for encouraging PA in girls at this age.

Consistent with evidence that PA and sedentary behavior frequently co-exist [49], we found that boys’ sedentary time was positively associated with a perception of their friends being ‘sometimes active’. Similar to previous research [24, 28], we also found no evidence of association between boys’ friendship networks and screen time, whereas higher out-degree and a lower proportion of very active friends were predictive of higher screen time on weekends for girls. Sex differences in personal network associations appear to reflect the nature of sedentary/ screen behavior. Whilst the majority of participants watched TV/videos/DVDs, boys were more likely than girls to play non-active computer games and spend more than two hours screen-time per day. In contrast, girls were more likely to engage in internet/social media usage. These results also suggest that having more active friends not only encourages PA participation, but provides social interaction outside of the school environment that may displace other recreational pursuits like screen-based recreational time.

**Strengths and limitations**

A major study strength was the use of both objective and self-report PA measures that enabled identification of different friendship associations within and outside of school contexts. Self-report was also a limitation, introducing potential risk of respondent bias. Participants’ perceptions of their friends’ behavior may also have bias. Yet inherent with perceptions of social norms theory [50], the study focus was whether perceptions, not the accuracy of assessment, were associated with behavior. The low participant response rate did not permit analysis of complete network characteristics such as in-degree, density or reciprocity. Instead, conducting ego (personal network) analyses provided the advantage of broadening the scope of friendships to those outside of school, an area currently understudied, which also enabled frequency of interaction with friends to be explored, giving insight into nuances of adolescent social behavior patterns. An additional limitation was the inability to determine underlying mechanisms (e.g. social influence/selection) leading to the observed network-behavior associations, due to the cross-sectional design. Further longitudinal research is needed to advance this knowledge.

**Conclusion**

This research suggests that PA and sedentary behaviors are associated with complex characteristics of children’s peer social environments. During late childhood/early adolescence peers are an important influence on behavior and these social mechanisms should be important aspects of intervention design to increase PA and reduce sedentary behaviors. These patterns are gendered particularly regarding timing and types of activity. Interventions might seek to provide opportunities and environments (e.g. parks, recreational facilities) for engaging in PA/sport with friendship groups, or to normalize being very active for both girls and boys.
Supporting Information

S1 Dataset. Physical activity, sedentary behavior and network characteristics dataset. (CSV)

Acknowledgments

We acknowledge the support of the Department of Education and Early Childhood Development, Victorian Catholic Education Diocese, participating schools and students, and data collectors who made this research possible. LMB is supported by an Alfred Deakin postdoctoral fellowship. SA is supported by funding from an Australian National Health and Medical Research Council/ Australian National Heart Foundation Career Development Fellowship (APP1045836). SA is a researcher on the US National Institutes of Health grant titled Systems Science to Guide Whole-of-Community Childhood Obesity Interventions (1R01HL115485-01A1). SA is a researcher within a NHMRC Centre for Research Excellence in Obesity Policy and Food Systems (APP1041020).

Author Contributions

Conceived and designed the experiments: JM SA LMB KDLH. Performed the experiments: JM. Analyzed the data: JM. Contributed reagents/materials/analysis tools: JM SA LMB KDLH. Wrote the paper: JM SA LMB KDLH.

References


This page marks a division between sections, and is intentionally blank.
Chapter 8: Friendship networks and change in obesogenic behaviour (Paper 4)

This chapter consists of an authorship statement for Paper 4, a longitudinal cohort study entitled: ‘Friendship networks as predictors of change in obesity risk behaviours in early adolescence’, followed by the manuscript itself.

Paper 4 addresses the following research question:

RQ4. Are friendship networks associated with a change in obesogenic behaviour?

Status of paper: Submitted for publication

An extended abstract of this paper was submitted and accepted by the journal indicated on the authorship statement. The journal subsequently invited a full manuscript to be submitted to the ‘Special Issue on the Coevolution of Networks and Health’ by 31 January 16 (Appendix F). As such, Paper 4 was under review at the time of thesis submission.
## AUTHORSHIP STATEMENT

### 1. Details of publication and executive author

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<td>Journal impact factor: n/a (new journal)</td>
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<th>Email or phone</th>
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<td>Jennifer Marks</td>
<td>School of Health &amp; Social Development, Faculty of Health</td>
<td><a href="mailto:mjenn@deakin.edu.au">mjenn@deakin.edu.au</a></td>
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<td>The TRANSFORM Study (Transition, School, Friends and Obesity Risk Models)</td>
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If there are multiple authors, give a full description of HDR thesis author’s contribution to the publication (for example, how much did you contribute to the conception of the project, the design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.)

JM designed and executed the study (conception, methodological design, data collection and statistical analyses). JM drafted, revised and submitted the manuscript with critical revision from co-authors.

*I declare that the above is an accurate description of my contribution to this paper, and the contributions of other authors are as described below.*

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<th>Name and affiliation of author</th>
<th>Contribution(s) (for example, conception of the project, design of methodology or experimental protocol, data collection, analysis, drafting the manuscript, revising it critically for important intellectual content, etc.)</th>
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<tr>
<td>Professor Steven Allender</td>
<td>Project conception, study design and critical revision of the manuscript</td>
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<tr>
<td>Principal supervisor</td>
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</tr>
<tr>
<td>Dr Kayla de la Haye</td>
<td>Study design, analytical advice and critical revision of the manuscript</td>
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<tr>
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iii. that the description in Section 4 of my contribution(s) to this publication is accurate,

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v. consent to the incorporation of the publication into the candidate’s HDR thesis submitted to Deakin University and, if the higher degree is awarded, the subsequent publication of the thesis by the university (subject to relevant Copyright provisions).

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6. Other contributor declarations
I agree to be named as a non-author contributor to this work.

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* If an author or contributor is unavailable or otherwise unable to sign the statement of authorship, the Head of Academic Unit may sign on their behalf, noting the reason for their unavailability, provided there is no evidence to suggest that the person would object to being named as author.

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Friendship networks as predictors of change in obesity risk behaviors in early adolescence

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Friendship networks as predictors of change in obesity risk behaviors in early adolescence

Abstract

Introduction

The aim of this study was to examine whether longitudinal characteristics of personal networks are associated with obesity-related behaviors from late childhood to early adolescence.

Methods

Two waves of physical activity (PA), screen time, and dietary recall data were collected from 308 students (99% retention), recruited from 15 primary schools in Victoria, Australia. At Time 1 (T1) participants were 11-13 years old. Time 2 (T2) was the following school year (5-8 months later). At each wave, participants described characteristics of up to fifteen friends. Regression models identified personal network characteristics that predicted health behaviors at T2.

Results

The proportion of friends that participants played sport with at T1 positively predicted T2 PA. For males, PA change across time was positively predicted by increases in the proportion of male friends, but negatively predicted by increases in the proportion of very active friends. An increase in the proportion of male friends also positively predicted energy-dense-nutrient-
poor food intake in males. Among females, an increase in the number of friends was
positively associated with increased weekend screen time.

Conclusion

Specific personal network characteristics predict change in several obesity-related behaviors from late childhood to early adolescence, a pivotal time for reinforcing healthy behaviors.

Key words: Child, Adolescent, Physical activity, Sedentary, Screen, Diet, Social networks
Introduction

Children and adolescents who are overweight or obese are at risk of preventable disease and related health consequences, both in the short and longer term (Reilly & Kelly, 2011). Addressing childhood overweight/obesity is a major problem, being highly prevalent (Ogden et al., 2012; World Health Organization, 2015) and complex, with multilevel ecological factors influencing behaviors that impact upon weight status (Huang et al., 2009). Risk behaviors of inadequate physical activity (PA), excessive sedentary behavior, and low-nutrient, energy-dense diets, are widespread (Leech et al., 2014), modifiable (Must et al., 2009), and track from childhood (Craigie et al., 2011). Understanding how these behaviors are modified is important in efforts to prevent development and tracking of obesity through to adolescence and adulthood.

The period from childhood to adolescence is also a time when peers exert stronger influence on behavior (Brechwald & Prinstein, 2011). This occurs through various social influence mechanisms, including social facilitation (where an individuals’ behavior is affected by the presence of others) (Triplet, 1898), and social learning processes, such as normative influence and behavior modelling or mimicry, where individual behavior is shaped by observing the behavior of others (Bandura, 1977). A deeper understanding of the mechanisms of peer influence that play out in adolescent social networks is necessary to identify effective pathways to promote healthy behaviors at a developmental stage when physical activity and healthy diets are often compromised. Theories of normative social influence suggest that individuals adopt behaviors of their peers to gain or maintain acceptance of the peer group (Aronson et al., 2005). In adolescence, peer norms have been shown to be predictive of attitudes or intentions to engage (or not) in physical activity and healthy eating behavior (Baker et al., 2003). Peer behavior is also likely to have effects on young people’s health.
behaviors that are less cognitively-mediated, such as by providing opportunities or constraints for particular behaviors (e.g., opportunities for active play), and via cues that influence behavior through unconscious and automated mimicry or modelling processes (Hermans et al., 2012; Salvy et al., 2012). Overall, these social influence processes are likely to give rise to similarities in obesity-risk behaviors among friends, and specifically tendencies for friends’ behaviors to positively predict changes in adolescent behavior over time.

Additionally, social facilitation processes are likely to result in increased or heightened behaviors among adolescents who have a greater number of friends.

Social relationships are dynamic, particularly throughout adolescence when there are regular changes in friendships and peer group affiliations. In particular, in countries where the period from late childhood to early adolescence is associated with a transition from primary to a discrete secondary school (compared to a middle school type environment that does not require a shift of school over this period), the school transition can have a very disruptive effect on friendship networks. Much of the evidence on the patterns we observe between network characteristics and obesity-related behavior within adolescence are based on cross-sectional studies, leading to calls for more longitudinal research to further understand the causal pathways of peer influence on behavior (Fletcher et al., 2011; Salvy et al., 2012; Sawka et al., 2013; Sawka et al., 2015). There are clear gaps in our understanding of how the many characteristics of peer networks e.g. from limited and mixed evidence, which reflect various peer characteristics and social influence mechanisms, differentially shape adolescent health behavior.

Social network analysis, an analytic method enabling the study of relationships between individuals and how relationship patterns relate to individual outcomes or behaviors
(Valente, 2010), is an ideal approach for characterizing peer relationships and testing their impact on obesity-related behaviors in adolescence. One suggested typology for describing changes in personal networks over time identifies various domains for analysis (Feld et al., 2007), which can be linked to relevant social influence phenomena. These include:

1) \textit{Changes in the size of a network.}

There is some evidence that obesity-related behaviors are associated with the size of adolescent friendship networks. Popularity, based on the number of friendship nominations received by an individual, has been positively associated with PA/sports participation (de la Haye et al., 2010; Sawka et al., 2014; Strauss & Pollack, 2003), higher total screen time (de la Haye et al., 2010; Sawka et al., 2014), less television screen time (Strauss & Pollack, 2003), and high calorie food consumption (de la Haye et al., 2010). These effects generally differ by behavior and gender, but may reflect processes of social facilitation, where a behavior is ‘facilitated’ through increased social connections; or normative influence, where popular adolescents are pressured to engage in socially desirable behavior to maintain their high social status.

Based on social facilitation theory, we expect that having a greater number of friends facilitates or ‘heightens’ eating and physical activity behaviors, by providing more motivation and opportunity to engage in particular behavior (e.g. more opportunities for PA engagement).

2) \textit{Persistent ties} (e.g. close friends; a person who is a friend of an individual from one time point to another).

Recent studies of friendship networks have found some similarities in physical activity, sedentary and dietary behaviors, often gender specific, amongst friends. Close friends are particularly important, with cross-sectional evidence showing the PA behaviors (e.g. organized sport participation, intensity, and amount of time engaged in PA) of close/best
friends positively predict males and females’ PA behavior in late childhood (aged 10-11) (Jago et al., 2011), and adolescence (aged 11-17) (Ali et al., 2011; de la Haye et al., 2010; Sawka et al., 2014; Sirard et al., 2013). However, there are also small number of cases where these network effects were not observed (e.g., de la Haye et al. (2010) found no evidence of close friend similarity in organized PA in one out of three peer networks), suggesting that there may be differences in social influence processes across networks that are not well understood. Longitudinal evidence of social network effects on PA is limited, although a small number of studies have found that friends’ PA predicts adolescent PA over time over and above the tendency to select friends with similarities in PA and demographics (de la Haye et al., 2011; Simpkins et al., 2013). The relationship between adolescent sedentary behavior and their close friends is even less clear. Cross-sectional studies show similarities in screen behavior among friends is more consistent within female networks (de la Haye et al., 2010), but inconsistent or inexistent within male friendship networks (de la Haye et al., 2010; Sirard et al., 2013). Longitudinal evidence in this area is also lacking.

Network associations with adolescent dietary intake is also mixed. Cross-sectional evidence reveals that adolescent consumption of low-nutrient energy-dense food has no association (Ali et al., 2011), or is positively associated (de la Haye et al., 2010; Wouters et al., 2010) with their best/close friends’ consumption of these foods. Positive associations in soft drink intake among adolescents and their best friends has also been observed (Wouters et al., 2010). Longitudinally, evidence of social influence was found within adolescent peer networks, where adolescent intake of low-nutrient energy-dense foods became increasingly similar to the intake of their close friends over a school year period (de la Haye et al., 2013). These social influence effects suggest that processes of normative influence or behavior modelling at least partially explains dietary similarities among close friends over time.
Based on social modelling theory where the behavior of valued peers is adopted by the individual (Bandura, 1977), and existing evidence of similarity of behavior amongst close friends, we may expect that the stability of a friendship over time (persistent ties) to be associated with less behavior change, i.e. adolescents are less likely to change their behavior where there is less disruption to their network.

3) Changes in network composition

Changes in other adolescent peer network characteristics (e.g. changes in network members, or the characteristics of network members), are relevant for furthering our understanding of peer influence on health behavior. We may expect, through social mechanisms of normative influence and behavior modeling, that increases in the proportion of friends who engage in a specific behavior, will predict increases in that behavior in the individual.

Cross-sectional evidence from the first phase of this study have examined network associations with PA and sedentary behaviors in late childhood. The aim of the current study is to further this work by examining whether longitudinal characteristics of personal networks, which reflect these various domains of network dynamics, are associated with changes in obesity-related behaviors (PA, sedentary, and dietary behavior) from late childhood to early adolescence. Based on the typology described by Feld et al. (2007), and the hypothesized social influence mechanisms outlined above, we examine the effect of: 1) changes in network size; 2) persistent ties (network stability); and 3) changes in relevant network characteristics (e.g. an increase in the proportion of active friends) on these behaviors. For further exploration (in addition to effects of network dynamics on behavior change over time), we also examine the potential lasting network effects of baseline network characteristics on later behavior.
Methods

Design and sample

The longitudinal study design (over two time points) and sampling methods as part of a broader study have been provided previously <<blinded for peer review>>>. Briefly, parental consent was received from 313 of 736 (43%) invited participants (age 11-13 years), recruited from 15 state government primary schools in Victoria, Australia. In addition to the reported sample of year 6 students (n=245), year 5 students (n=65) also participated within the current study at the request of schools within one region. Over the time 1 (T1) to time 2 (T2) period, 50% of students changed schools when transitioning from primary to secondary school, where we would anticipate a greater change in social networks than for students who did not change their school environment. Informed written parental consent was obtained for all participants. Additional verbal assent was obtained from each participant at each stage of data collection and participants were free to withdraw or choose not to participate at any stage without any consequence. T1 data collection was conducted in the final term (Oct-Dec) of the 2013 school year with 310 consenting students (three students were unavailable to participate). T2 data collection was conducted 5-8 months later in term 2 of the following school year (April-June 2014) from 42 schools, with 308 of the original students participating (99% retention rate). At both time points anthropometric (height and weight) measures were taken by trained researchers, participants completed a self-report behavior and social network questionnaire, and were given an accelerometer to wear for a period of one week. Analyses were conducted from 308 students with data at both time points only. Ethics clearance was obtained from the university human research ethics committee and permission to approach schools was received from the relevant state school authority <<blinded for peer review>>>. 
Objective measures: Accelerometry and anthropometrics

Accelerometry methods have been described previously within the broader study for peer review. In brief, ActiGraph accelerometers (ActiGraph LCC, Pensacola, US) were issued to all students at T1 and 157 students (year 7 secondary school students only) at T2 (due to limited availability). Minimum wear time of 480 minutes over three 8 hour days was considered valid data for analysis using Evenson equation cut points for categorization of sedentary, light PA and moderate to vigorous physical activity (MVPA) (Trost et al., 2011). Valid paired data from T1 to T2 was received from 127 students. Intra-class correlations (ICC) were conducted to test for clustering of students who did, or did not wear an accelerometer at T2. No significant differences for weight status or self-report PA were found at T1 between students who did not have valid accelerometer data at T2.

Protocols for anthropometric measurements have previously been described for peer review. Weight status was defined and calculated using the World Health Organization’s age-specific body mass index cut-points (de Onis & Lobstein, 2010). Weight status (0= not overweight/obese; 1= overweight/obese) was included as a control variable as a predictor of network characteristics, and potential confounder for engaging in obesity-related behavior.

Self-report behavior

Methods to collect self-report data have been described previously, through application of validated PAQ-C (Kowalski et al., 2004), CLASS (Telford et al., 2004), and ABAKQ (Department of Health, 2011) surveys. In brief, participants were
asked to report the amount of time in the last 7 days they engaged in ‘sports, dance or play games’ in which they were ‘very active’ right after school, on school evenings and on the last weekend. Times being very active after school and on school evenings were added together, then divided by five to give an average weekday of being very active outside of school hours. Time being very active on weekends was divided by two to give a daily weekend average. To assess physical activity intensity during school recess and lunch breaks, students were asked to record what they did ‘most of the time’ in the last 7 days, on a 5-point Likert scale (from 1: sit down to 5: run around most of the time). Two active transport questions asked for frequency of walking and cycling/scotting to or from school ‘in the last 5 school days’ (0-10 times). Screen-based questions were on usual activity (yes/no) on a typical school day and weekend, and amount of time spent (hours and minutes) watching TV/videos/DVDs, playing non-active computer games and using a computer for leisure. Time for each screen based activity was aggregated to give recreational screen time totals separately for a typical weekday and weekend. Weekend screen time was then divided by two to give a daily weekend total.

As previously reported <<blinded for peer review>>, self-report dietary intake survey questions were taken from the Eat Well Be Active validated questionnaire (Wilson et al., 2008). To assess dietary intake on a typical school day, participants were asked to identify “what they usually eat/drink” during three specific times of day: recess, lunch, and after school. For each of the three time periods they could select multiple response options from the following eleven non-core food items (energy-dense nutrient-poor foods) and three sugar-sweetened beverage items: potato chips, chocolate, lollies (candy), muesli/fruit bars, savory biscuits, sweet biscuits, ice cream, hot chips/fries, pies/pasties/ sausage rolls, hot dogs, pizza, other non-core food (if applicable), cordial (flavored sugar-based drink), fruit juice/drink and
regular soft drink. To compute a total score for daily intake of non-core foods and sweetened beverages, each item was given a score of 1 at each mention, with a potential maximum score of 33 for non-core foods (i.e., 11 items each consumed at recess, lunch, and after-school: $11 \times 3 = 33$), and 9 for sweetened beverages (3 items x 3 times of day). Additional Likert scale questions asked for usual frequency of consumption of 3 non-core food items (potato chips, chocolate/lollies and hot chips) and 2 beverage items (fruit juice/drink; soft drink) from 1 = *never/rarely*, to 5 = *every day*. As per the validated survey design (Wilson et al., 2008), Likert scale items were divided by 7 to give a representative daily score (potential maximum score: non-core foods 2.1; sweetened beverages 1.4). Likert score items were added to their respective non-core food and sweetened beverage school-day total to give separate total scores for non-core food (range 0-35.1) and for sweetened beverage intake (range 0-10.4).

**Personal friendship networks**

At each assessment, as per the first cross sectional phase of the study <<blinded for peer review>>, participants were asked to list the full name and gender of up to fifteen friends (not restricted) who they “hang around with the most”, indicating times/settings (recess, lunch, after school, and/or weekends) they engage with each friend. A ‘friends with very frequent contact’ variable was derived by identifying the proportion of friends the participant engaged with at least three times/settings (out of four possible settings: recess, lunch, after school, and on weekends), representing friendships that exist both inside and outside of school.

Additional characteristics of their friends and their relationships with each friend relevant to social influence on the focal dependent behaviors were also measured, using standard personal social network items (Crossley et al., 2015). For each friend, participants indicated:
1) if they play sport with the friend ‘more than once a week’; 2) whether they perceive the friend to be very active; and 3) whether they perceive the friend to eat ‘very healthy’.

Variables that summarize the characteristics of participants personal friendship network were computed at each time point representing: 1) the total number of nominated friends (out-degree); and the proportion of their nominated friends that are: 2) same-sex friends; 3) friends with very frequent contact; 4) friends they play sport with; 5) very active friends; and 6) very healthy (dietary) friends.

These summary network characteristics at each time point were then used to compute variables capturing key domains of network dynamics. Change in network size was derived by subtracting participant’s out-degree at T2 from their out-degree at T1 (where a positive value represents an increase in the number of friends from T1 to T2). The stability of friendships was based on a count of friends that were nominated by the participant at both T1 and T2, and calculated as a proportion of the total count of unique nominated friends over the two waves. Changes in network characteristics were computed by subtracting the proportion of an adolescents’ friends with a particular characteristic at T1, from the proportion of their friends with this same characteristic at T2. Positive values represent an increase in the proportion of a particular characteristic from T1 to T2 (e.g. an increase in the percentage of total friends that are active from Time 1 to Time 2).

**Statistical analyses**

Descriptive summary statistics for all behavior and network characteristic variables were conducted separately by gender at T1, T2 and change from T1 to T2. Analysis of change
from T1 to T2 was conducted for participants with valid data at both time points using paired t-test of means or exact McNemar paired test of proportions as appropriate. Regression models were used to investigate the effect of personal network characteristics on individual behavior, with separate analyses for males and females given consistent evidence that these effects differ by gender. Network variables used as predictors of change in behavior from T1 to T2 were: 1) change in network size, 2) the proportion of stable friends, and 3) changes of each summary network characteristic from T1 to T2. Additionally, to explore the potential lasting effects of baseline network characteristics on later behavior, models were also specified to test if T1 network composition variables (‘the proportion of very active friends’, ‘the proportion of friends participants played sport with’, and ‘the proportion of friends who eat very healthy’), predicted relevant PA and dietary behavior of participants at T2.

Any highly correlated predictor variables were not included within the same model. All models controlled for participant age and weight status at baseline, and models predicting behavior at T2 (but not behavior change from T1 to T2) controlled for T1 behavior. Within models predicting a change of behavior from T1 to T2, ‘changing school’ (0=no; 1=yes), and differences in accelerometer wear time (for models predicting a change in accelerometer derived PA), were also included as controls. Clustering at the school level was assessed using intra-class correlation tests, and accounted for in multilevel regression models. Linear and Poisson regression were used to model continuous and count outcome variables respectively. Using a forward selection approach, predictor variables with significant effects at p < 0.05 were included and retained within each model. All analyses were conducted in 2015 using Stata 12.0 software (StataCorp LP, College Station, US).
Results

Descriptive characteristics

Three hundred and eight students (58% female) participated at both T1 and T2. At T1 mean age was 12.1 (male), 12.0 (female) years. Forty-four percent of males and 34% of females were overweight or obese at T1, with no significant change by T2.

PA intensity during school time decreased for both males and females, whereas time spent in MVPA after school increased for males (Table 1). Sedentary and recreational screen time significantly increased on average for females, but not for males. Non-core food intake for males and females, and sweetened beverage intake for females, all decreased from T1 to T2.

Personal network characteristics

On average, females nominated more friends (T1: 6.5; T2: 6.7) than males (T1: 5.5; T2: 5.8), with 29% of male and 23% of female friendships remaining stable over time (Table 2). Students who did not change schools had higher network stability (males 36%; females 30%) than students who changed schools (males 21%; females 16%) from T1 to T2. The majority of nominated friends were of the same sex as the participant, with girls increasing their proportion of male friends at T2. The average proportion of very active friends (for males only) and friends that participants played sport with (for males and females), significantly decreased from T1 to T2. The average proportion of friends with very frequent contact and friends perceived to ‘eat very healthy’, did not change significantly over time.
Male personal networks and behavior

Network characteristics as predictors of 1) a change of behavior, and 2) behavior at T2 in males are given per behavior model in Table 3. No significant models were found for self-report (SR) after-school MVPA, screen time, or sweetened beverage intake. Network characteristics ‘friends with very frequent contact’ and the proportion of ‘stable’ friends were not significant predictors of male PA, sedentary or dietary behavior.

Change of behavior from T1 to T2

Among males, an increase in network size was positively associated with an increase in PA intensity (SR) at school lunch breaks, whilst an increase in the proportion of very active friends was predictive of an increase PA intensity (SR) at recess. An increase in the proportion of male friends was also predictive of an increase in: MVPA on weekends; recess and lunch PA intensity; and frequency of cycling to/from school.

For the sample of participants with objectively measured PA data, an increase in the proportion of very active friends predicted a decline in average daily MVPA, and also predicted an increase in average daily sedentary time.

An increase in the proportion of friends who ‘eat healthy’ was not associated with a change of dietary intake, however an increase in non-core food intake was positively predicted by an increase in the proportion of male friends, and negatively predicted by an increase in the proportion of friends participants played sport with.

T1 network characteristic as predictor of T2 behavior

Among males, having a higher proportion of their total friends who were perceived as being very active at T1 was predictive of more overall time spent in MVPA, higher PA intensity
(SR) at recess and lunch, and less sedentary time, at T2. A higher proportion of friends that participants usually played sport with at T1 was also positively associated with higher PA intensity (SR) at recess and lunch, and more time spent in MVPA on weekends (SR), at T2.

The proportion of friends that were perceived to eat ‘very healthy’ at T1, was predictive of less frequent purchases of after-school snacks at T2.

Female personal networks and behavior

Similar to males, having a high proportion of friends to play sport with was predictive of PA behavior in females (Table 4). In contrast, fewer network characteristics were identified as significant predictors of female behavior, compared to males.

Change of behavior from T1 to T2

Among females, an increase in the proportion of friends participants usually play sport with, was predictive of an increase in PA intensity (SR) at school lunch times. An increase in network size was predictive of an increase in weekend recreational screen time. Two network characteristics predicted an increase in sweetened beverage intake: a greater proportion of stable friends and an increase in the proportion of female friends.

T1 network characteristic as predictor of T2 behavior

For females, having a higher percentage of friends they played sport with at T1 predicted greater PA time and intensity at T2 (Table 4). No baseline network characteristics were predictive of sedentary or dietary behavior at T2.
Discussion

Specific characteristics of friendship networks from late childhood to early adolescence were associated with shifts in various physical activity, sedentary and dietary behaviors. Results from this study do not consistently support the proposed hypotheses. For example, an increase in the size of friendship groups generally did not increase PA or eating behavior over time, whilst an increase in the proportion of very active friends had a negative effect on PA for males. Results suggest support for the hypothesis that network stability is not associated with behavior change for PA and sedentary behaviors. We also found lasting network effects of having active friends at baseline to be predictive of more PA (time/intensity), over time.

One important conclusion is that the complexity and differences in dynamic network processes that influence behavior change need to be considered, particularly differentiating the effect of characteristics within male and female networks.

Unlike prior research, we did not find that having more friends was associated with an increase in average daily PA. Sawka et al. (2014) and de la Haye et al. (2010) found that popularity, measured by in-degree (i.e. number of friendship nominations received by others), was associated with greater PA. Because the current study had data on personal friendship networks (rather than complete reciprocated networks), and so did not have a valid indicator for popularity (i.e., in-degree) we could not test this effect. However, personal network data does allow us to test network size (i.e., nominations sent, or out-degree) which is not a measure of social status but does capture differences in social connectedness, and thus assesses somewhat different social influence mechanisms. Our results suggest a social facilitation effect from an increase in out-degree to provide more opportunity for particular behaviors. For males, this may also be a reflection of the school environment providing
opportunity (e.g. equipment, facilities) (Ridgers et al., 2012) for engaging in group PA, where
more nominated friends was associated with an increase in PA intensity within school lunch
breaks. Whereas for females, nominating more friends had a social facilitation effect on
behavior (increased screen time) outside of school hours. For girls, an increase in the number
of friends may equate to more time engaging in social media, given evidence that girls spend
more time on weekends socializing with friends from early adolescence (Hardy et al., 2007).
Identifying with having more friends for facilitating behavior appears to be an important
difference by gender, context, and by type of behavior.

We explored whether there was any association between network stability and behavior, and
found minimal evidence that this predicted behavior change. Friendships can be created and
dissolved, without much change to the size of a network (Feld et al., 2007). Within the
current study, there was little change to the size of personal networks, with an average of two
from five or six friends persisting over time. In general, we did not find an effect on behavior
from the proportion of stable friendships. There is little similar research to draw comparisons
and conclusions for these results. Whilst the behaviors of close friends have been predictive
of certain behaviors (Ali et al., 2011; de la Haye et al., 2010, 2013; Jago et al., 2011; Sawka
et al., 2014; Wouters et al., 2010), we also did not find closeness (measured by frequency of
contact) of friends, a potentially related characteristic to network stability, to be a factor.
Consistent with these studies in late childhood/early adolescence, networks were also largely
gender homophilous, although for girls there were significantly more cross-gender
friendships by T2. For example we found a change in the gender mix of friends having an
effect on behavior, particularly for boys where an increase in the proportion of male friends
over time was predictive of an increase in MVPA time and PA intensity. It is also difficult to
interpret whether no change in behavior demonstrates any influence from persistent ties
within a network. Further research on the characteristics of a stable dyadic friendship, compared to a dissolved dyadic friendship, would be valuable to explore.

We found mixed evidence for the hypothesis that an increase in the proportion of active and/or sporting friends was predictive of an increase in PA over time. Consistent with PA studies with best friends, where exercise or sport participation was more likely if the friend participated also (Ali et al., 2011; de la Haye et al., 2010), having an increase in the proportion of active/sporting friends was predictive of an increase in PA intensity. Unlike Jago et al. (2011) in their study of 10-11 year old children who found increases in objectively measured MVPA when engaging with best friends outside of school hours, findings of friendship associations with increased PA intensity within the current study was within the school day only, and not specifically with best/close friends. A difference could be due to type of measurement, however we also found (within the sample of students with valid accelerometer data), an increase in the proportion of ‘very active’ friends was predictive of a decline in average daily MVPA (and increase in sedentary time). It may be that MVPA engagement with friends differs by age and context. After the shift to secondary school when PA is in decline, having more active friends may be important for PA during the school day, but have little impact on the decline in PA overall. That is, the school environment may provide opportunity for engaging in sport/PA with clusters of peer groups of similar activity interests, outside of time spent with best/close friends. This suggests the type (e.g. organized sport) and PA intensity by context (e.g. within/outside of school) is of consequence, and implies targeting intervention according to context is critical to promote PA amongst different peer groups.
We further explored whether behavioral characteristics of networks within late childhood would have lasting effects into early adolescence. Minimal associations were found between the proportion of ‘healthy eating’ friends at baseline and later dietary behavior. Similarities of unhealthy food consumption amongst adolescent friends has been shown to increase over time, after controlling for any initial similarities that may have arisen through friendship selection (de la Haye et al., 2013). Our study using perceptions of healthy eating did not show evidence of behavior modelling in the same social context, with network stability (for girls) and gender mix being more influential on dietary behavior than perceptions of friends’ dietary behaviors. However we found evidence of lasting effects of PA-related network characteristics on PA intensity/frequency. Playing sport with friends (and for boys, having very active friends) in late childhood was a strong predictor of increased PA time and intensity in early adolescence. Longitudinal studies (de la Haye et al., 2011; Denault, 2009; Jago et al., 2012) offer different perspectives for PA engagement amongst friends over time. Jago et al. (2012) found friendship support associated with girls participating in PA over a change of school environment, whilst de la Haye et al. (2011) found various mechanisms of social influence and selection to be predictive of adolescent PA behavior, particularly for close friends to adopt the behavior of others. Within the current research where similarity of behavior amongst friends predicted later PA engagement, the selection of friends of similar sporting interest may have been a dominate mechanism having a lasting effect (albeit over a relatively short period), rather than behavior modelling over time. It is also likely that shared opportunities to engage in PA both within and outside of the school environment is also a contributing factor for increasing PA in early adolescence.
Strengths and limitations

The inclusion of multiple network characteristics for exploration of impacts on behavioral norms was a study strength. The study also benefited from very high retention rate of participants between T1 and T2. Self-reported behavioral data may also introduce bias, with the potential for under or overestimation. The study was strengthened by the use of objective PA measures for a proportion of participants, results showing consistency with current behavioral trends, such as declining PA and increasing sedentary behavior in adolescence. The relatively low response rate of participants did not allow complete networks and reciprocity of network information between all pairs of friends to be analyzed. This limitation did not restrict the current study design using personal (ego) networks, appropriate for exploring relationships between individual network characteristics and behavior.

Conclusion

Harnessing peer influence for the promotion of healthy weight-related behaviors appears important during late childhood and early adolescence. With various mechanisms of influence impacting upon behaviors which generally differ by gender, it is important to consider the social context for effective intervention. For example harnessing social facilitation of normative behavior could involve providing more opportunities for gender based sporting group activities during the school day and on weekends. With sports participation being relatively stable in adolescence (Denault, 2009), and our findings of increased PA in different contexts potentially from the selection of active friends, increasing PA participation from late childhood should be a high priority. Given the social facilitation effect for girls having more friends equating to increased screen time, policy or practice
effectiveness for reducing screen time is more challenging. Similarly, for dietary behavior, intervention needs to consider the social context where unhealthy food/drink is consumed. For example, it may be more effective to establish healthy eating policies at school and provide less opportunity to consume unhealthy food/drink, than to modify friendship networks. More is needed to understand how to modify the adolescent social environment to promote healthy behavior, and in particular how to engage with different behaviors in the different contexts most amenable to peer influence. Harnessing peer influence to modify behavioral norms for encouraging healthy weight from late childhood through to adolescence remains an additional and potentially powerful area for further study.
References


Table 1: Physical activity, sedentary and dietary behavior by sex at Time 1, Time 2 and change (Time 1 to Time 2)

| Behavior: Physical activity | Male (N=128) | | | | | | Female (N=180) | | | |
|---|---|---|---|---|---|---|---|---|---|
| | n | Time 1 | Time 2 | Change | p | n | Time 1 | Time 2 | Change |
| MVPA average daily (min) | 42 | 58 (17) | 56 (20) | -2 (15) | 0.404 | 85 | 49 (17) | 44 (15) | -4 (12) | 0.002 |
| MVPA after school (min) | 125 | 69 (53) | 92 (75) | 24 (77) | 0.001 | 175 | 64 (58) | 71 (67) | 7 (67) | 0.160 |
| MVPA daily weekend (min) | 128 | 99 (80) | 94 (91) | -5 (111) | 0.577 | 178 | 78 (87) | 84 (89) | 6 (116) | 0.486 |
| PA level at recess | 124 | 3.9 (1.2) | 3.1 (1.4) | -0.8 (1.6) | <0.001 | 172 | 3.1 (1.2) | 2.4 (1.1) | -0.7 (1.4) | <0.001 |
| PA level at lunch time | 125 | 4.1 (1.1) | 3.2 (1.4) | -0.9 (1.5) | <0.001 | 174 | 3.3 (1.2) | 2.7 (1.2) | -0.7 (1.4) | <0.001 |
| Walk to/from school (times/week) | 127 | 2.7 (3.6) | 2.5 (3.6) | -0.2 (3.7) | 0.504 | 180 | 2.7 (3.7) | 2.8 (3.8) | 0.0 (3.9) | 0.938 |
| Cycle to/from school (times/week) | 128 | 1.5 (2.9) | 1.0 (2.7) | -0.4 (2.9) | 0.088 | 180 | 0.9 (2.2) | 0.4 (1.4) | -0.5 (2.5) | 0.007 |
| Behavior: Sedentary / screen time | | | | | | | | | |
| Sedentary average daily (mins) | 42 | 467 (66) | 480 (90) | 13 (88) | 0.339 | 85 | 481 (71) | 498 (84) | 17 (69) | 0.028 |
| Recreational weekday screen time (min) | 126 | 141 (124) | 151 (113) | 10 (128) | 0.402 | 178 | 111 (93) | 135 (109) | 24 (111) | 0.005 |
| Recreational weekend daily screen time (min) | 126 | 160 (149) | 150 (161) | -10 (168) | 0.522 | 177 | 113 (89) | 149 (143) | 36 (142) | 0.001 |
| Behavior: Dietary | | | | | | | | | |
| Non-core food score (range 0-35) | 127 | 4.4 (2.9) | 3.7 (2.1) | -0.7 (2.8) | 0.004 | 178 | 5.0 (4.6) | 3.8 (2.3) | -1.2 (4.4) | <0.001 |
| Sweetened beverage score (range 0-11) | 123 | 1.9 (1.4) | 1.8 (1.3) | -0.1 (1.5) | 0.436 | 175 | 1.9 (1.5) | 1.5 (1.0) | -0.3 (1.3) | 0.001 |
| Buy snack food after school (1: never/rarely, to 5: every day) | 128 | 2.0 (1.0) | 1.8 (0.9) | -0.1 (1.2) | 0.222 | 180 | 1.9 (1.0) | 1.9 (0.9) | 0.1 (1.0) | 0.405 |

MVPA, moderate to vigorous physical activity; PA, physical activity; SD, standard deviation

1. Objectively measured; 2. Self-report measure; 3. Change from Time 1 to Time 2 conducted for participants with valid data at both Time 1 and Time 2 only

p, test value for difference between Time 1 & Time 2 total using paired t-test of means or exact McNemar paired test of proportions as appropriate; bold value: p < 0.05
Table 2: Personal friendship network characteristics at Time 1, Time 2 and change (Time 1 to Time 2), by sex

<table>
<thead>
<tr>
<th>Personal network characteristic</th>
<th>Male (n=128)</th>
<th>Female (n=180)</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Time 1</td>
<td>Time 2</td>
<td>Change</td>
<td>Time 1</td>
</tr>
<tr>
<td>Network size (out-degree)</td>
<td>M (SD, Ra)</td>
<td>M (SD, Ra)</td>
<td>M (SD)</td>
<td>M (SD, Ra)</td>
</tr>
<tr>
<td>% of stable friends between T1 &amp; T2</td>
<td>29 (25.0-100)</td>
<td>29 (25.0-100)</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>% of stable friends (change of school)</td>
<td>21 (17.0-67)</td>
<td>21 (17.0-67)</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>% of stable friends (no change of school)</td>
<td>36 (27.0-100)</td>
<td>36 (27.0-100)</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>% of same sex friends</td>
<td>93 (17.0-100)</td>
<td>93 (17.13-100)</td>
<td>0 (17)</td>
<td>0.870</td>
</tr>
<tr>
<td>% friends with very frequent contact</td>
<td>28 (35.0-100)</td>
<td>29 (36.0-100)</td>
<td>1 (40)</td>
<td>0.797</td>
</tr>
<tr>
<td>% usually play sport with</td>
<td>69 (37.0-100)</td>
<td>64 (39.0-100)</td>
<td>-5 (41)</td>
<td>0.028</td>
</tr>
<tr>
<td>% of 'very active' friends</td>
<td>67 (35.0-100)</td>
<td>60 (36.0-100)</td>
<td>-7 (39)</td>
<td>0.027</td>
</tr>
<tr>
<td>% friends who eat 'very healthy'</td>
<td>52 (41.0-100)</td>
<td>52 (41.0-100)</td>
<td>0 (49)</td>
<td>0.957</td>
</tr>
</tbody>
</table>

M, mean; n/a, not applicable; PA, physical activity; Ra, range; SD, standard deviation; T1, time 1; T2, time 2; 
p, test value for differences from T1 to T2 using t-test of means; bold indicates p < 0.05.

1. Where 'change of school' denotes participants who changed (or did not change) schools from T1 to T2.
2. Frequency of contact at least 3 of 4 from recess, lunch, after school or weekends.
### Table 3. Regression model coefficients of personal network characteristics as predictors of physical activity, sedentary and dietary behavior for males

<table>
<thead>
<tr>
<th>Physical activity</th>
<th>Change in behavior from increase in network characteristic T1 to T2</th>
<th>T2 behavior by network characteristic at T1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef</td>
<td>95% CI</td>
</tr>
<tr>
<td>MVPA accelerometer (min/day)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>△ % of ‘very active’ friends</td>
<td>-21.48</td>
<td>-35.06, -7.9</td>
</tr>
<tr>
<td>△ % of ‘very active’ friends @ T1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Recess PA (SR) intensity (1: sit down, to 5: run around)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>△ % of same sex friends</td>
<td>1.90</td>
<td>0.37, 3.44</td>
</tr>
<tr>
<td>△ % of ‘very active’ friends</td>
<td>0.71</td>
<td>0.04, 1.39</td>
</tr>
<tr>
<td>△ % of friends ‘usually play sport with’ @ T1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lunch PA intensity (1: sit down, to 5: run around)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>△ Total friends (out-degree)</td>
<td>0.11</td>
<td>0.04, 0.17</td>
</tr>
<tr>
<td>△ % of same sex friends</td>
<td>1.44</td>
<td>0.05, 2.84</td>
</tr>
<tr>
<td>△ % of friends ‘usually play sport with’ @ T1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>△ % of ‘very active’ friends</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weekend MVPA SR (min/day)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>△ % of same sex friends</td>
<td>138.11</td>
<td>22.83, 253.39</td>
</tr>
<tr>
<td>△ % of friends ‘usually play sport with’ @ T1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cycle to/from school (no. of times)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>△ % of same sex friends</td>
<td>3.50</td>
<td>0.46, 6.55</td>
</tr>
</tbody>
</table>

### Sedentary behavior

<table>
<thead>
<tr>
<th>Sedentary accelerometer (min/day)</th>
<th>Coef</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>△ % of ‘very active’ friends</td>
<td>54.46</td>
<td>12.38, 96.54</td>
<td>0.013</td>
</tr>
<tr>
<td>△ % of ‘very active’ friends @ T1</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

% of ‘very active’ friends @ T1 | -55.41  | -89.7, -21.04 | 0.005 |
<table>
<thead>
<tr>
<th>Dietary behavior</th>
<th>Coef</th>
<th>95% CI</th>
<th>p</th>
<th>Coef</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-core food score (range 0-35)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δ % of same sex friends²</td>
<td>4.40</td>
<td>1.36, 7.44</td>
<td>0.005</td>
<td>NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δ % friends usually play sport with²</td>
<td>-1.48</td>
<td>-2.76, -0.2</td>
<td>0.024</td>
<td>NA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>After-school snack frequency (1: never/rarely, to 5: every day)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of 'very healthy' friends @ T1²</td>
<td></td>
<td></td>
<td></td>
<td>NS</td>
<td>-0.40</td>
<td>-0.76, -0.03</td>
</tr>
</tbody>
</table>

Δ, change (increase) from T1 to T2; MVPA, moderate to vigorous physical activity; NA, not applicable/tested; NS, not significant; PA, physical activity; SR, self-report; T1, time 1; T2, time 2; bold values indicate p<0.05

Note. All models controlled for age and weight status; Objective PA models controlled for accelerometer wear time; 'Change of school' was included as a control variable if a statistically significant predictor of behavior or network change

1. Valid accelerometer data comparison from time 1 to time 2 for 33% of participants only
2. Increase in network characteristic as predictor of behavior change from T1 to T2
3. Network characteristic at T1 as predictor of T2 behavior, within model controlling for T1 behavior and school level at T1
Table 4. Regression model coefficients of personal network characteristics as predictors of physical activity, sedentary and dietary behavior for females

<table>
<thead>
<tr>
<th>Physical activity</th>
<th>Change in behavior from increase in network characteristic T1 to T2</th>
<th>T2 behavior by network characteristic at T1</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Coef</td>
<td>95% CI</td>
</tr>
<tr>
<td>After school MVPA (SR) (min/day)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of friends 'usually play sport with' @ T1¹</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Weekend MVPA (SR) (min/day)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of friends 'usually play sport with' @ T1¹</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Lunch PA (SR) intensity (1: sit down, to 5: run around)</td>
<td>0.59</td>
<td>0.13, 1.05</td>
</tr>
<tr>
<td>Δ % of friends usually play sport with²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cycle to/from school (no. of times)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of friends 'usually play sport with' @ T1¹</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Sedentary screen-time behavior</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δ Weekend recreational screen time (min/day)</td>
<td>11.41</td>
<td>5.96, 16.86</td>
</tr>
<tr>
<td>Δ Total friends (out-degree)²</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dietary behavior</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Δ Sweetened beverage score (range 0-11)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>% of stable friends</td>
<td>1.36</td>
<td>0.23, 2.50</td>
</tr>
<tr>
<td>Δ % of same sex friends²</td>
<td>0.89</td>
<td>0.03, 1.76</td>
</tr>
</tbody>
</table>

Δ, change (increase) from T1 to T2; MVPA, moderate to vigorous physical activity; NA, not applicable/tested; NS, not significant; PA, physical activity; SR, self-report; T1, time 1; T2, time 2; bold values indicate p<0.05

Note. All models control for age and weight status; 'Change of school' was included as a control variable if a statistically significant predictor of behavior or network change
1. Network characteristic at T1 as predictor of T2 behavior, within model controlling for T1 behavior and school level at T1
2. Increase in network characteristic as predictor of behavior change from T1 to T2
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Part C: Discussion and Conclusion

Chapter 9 Discussion

9.1 Introduction

Part C of this thesis presents a discussion of the overall results of the study as a complete body of work. In Chapter 9, main findings and their significance are presented and discussed by research question. This is followed by strengths and limitations of the overall study, implications of results, and suggestions for future research. Chapter 10 draws the thesis to a final conclusion.

9.2 Main findings

The principal aim of TranSFORM was to explore the impact of a shift of school environment on obesogenic behaviours as children transition from primary to secondary school. The secondary aim was to examine the influence of friendship networks on behaviour change over this period. Findings confirmed that a disruptive change of environment in early adolescence can have a detrimental effect on physical activity, sedentary and dietary behaviour, and that nuanced and contextual characteristics of friendship networks have an effect on these behaviours over this period. The following section presents a discussion of major findings, results of corresponding hypotheses, and significance by research question. This section ends with the presentation of a conceptual model of influences for one sampled behaviour (i.e., PA intensity at school breaks).

9.2.1 RQ1. Do obesogenic behaviours change as children transition from primary to secondary school?
Findings of this study support the hypothesis that some obesogenic behaviours increase over the transition from primary to secondary school, irrespective of whether this includes a shift of school environment (i.e., a change in school) as students move from one school year-level to the next.

The findings from paper 1 demonstrated that PA declines and sedentary behaviour (including screen time) increases over this period, which in Australia and in many other countries corresponds to the period from late childhood to early adolescence. These results are consistent with current and concerning trends of inadequate PA in the years encompassing childhood to adolescence, increasing the risk of obesity and associated health risks (Biddle et al. 2010; Boreham & McKay 2011; Costigan et al. 2013; Craige et al. 2011; Jago et al. 2005; Mitchell et al. 2013; Must & Tybor 2005; NSW Government 2011; Rezende et al. 2014; Sisson et al. 2009; World Health Assembly 2004). Similarly, consistent with national survey data of declining fruit and vegetable intake throughout childhood (Department of Health 2011; Department of Health and Ageing 2007), results from paper 2 showed a decrease in fruit and vegetable intake over the study period.

Yet not all obesogenic behaviours deteriorated over the school transition, shown by a small but significant decrease in non-core food and sweetened beverage intake. There are few other longitudinal studies to provide comparative evidence. What evidence there is suggests that much earlier trends of increasing sweetened beverage and snack food intake, as shown in the Bogalusa longitudinal heart study between 1973 and 1991 with children followed through to early adulthood (Demory-Luce et al. 2004), may be stabilising or in decline. A more recent longitudinal study with Australian children and adolescents aged 10-12 at baseline, found a reduction in energy-dense dietary intake over a three year period (Leech et al. 2014). The TranSFORM study provides a further perspective to this decline, by finding a change in dietary intake over the primary to secondary school transition, a significant and potentially disruptive life stage.
Whilst parental influence on diet throughout childhood is strong (Pedersen, Gronhøj & Thogersen 2015; van der Horst et al. 2007), there is currently little evidence on the influence of the school environment on snack food or sweetened beverage consumption (van der Horst et al. 2008).

Unique within the current study was the particular focus for identifying change in PA, sedentary and dietary behaviours between childhood and adolescence to coincide with the transition from primary to secondary school. Findings from this research question clearly show the school transition to impact upon obesogenic behaviour. The intentional study design was to allow for further exploration of the effect on behaviour from a change of school environment (refer to the next section). In the past decade, research into childhood obesity has established that environments are a key influence on obesogenic behaviour (Egger & Swinburn 1997; World Health Organization 1986), which for school age children, the home and school environment where much time is spent, are particularly important (Langford et al. 2015). Results of this study identifying change in obesogenic behaviours over the period from childhood to adolescence, coinciding with the period of transition from primary to secondary school, raises the question whether a change of school environment was a significant factor of behaviour change. This work was the aim of RQ2.

9.2.2 RQ2. Is there greater change of obesogenic behaviours for students who change their school environment?

Findings of this study supported the hypothesis that students who change their school environment would have a greater change in behaviour than students who do not change school over the transition from primary to secondary school. This was tested by comparing differences in behaviour change between two cohorts of students, i.e., between a cohort of students who attended a different school when transitioning from primary to secondary school, and a cohort of students who remained in the same combined primary to secondary school.
system over the same period. In papers one and two the hypothesis was examined with respect to PA and food respectively. Paper one demonstrated an unfavourable change in obesogenic behaviours as students who changed schools had a greater reduction of within-school PA intensity (one point of a 5 point intensity scale) and a greater increase in screen time (e.g., 42 mins/day on weekdays). The decline in longitudinal PA intensity is consistent with evidence of students engaging in less MVPA at recess in secondary school compared to primary school (Ridgers et al. 2012). Paper two demonstrated unfavourable changes in obesogenic dietary behaviour for students who changed school. Whilst all students on average decreased their sweetened beverage intake, students who changed school had a relatively smaller (and statistically significant) decrease in intake than those who did not change school. Students who changed schools also experienced an increase in after-school snack food purchase frequency (compared to a decrease in students who did not change school). Comparison with other longitudinal studies is difficult as there are no comparative studies on the impact of a change of school environment measuring sedentary or dietary behaviour change. For MVPA, results differ between studies, where MPVA has been observed to both increase and decrease over the school transition, distinguished by type of PA measurement and time engaged in PA (De Meester et al. 2014; Jago, Page & Cooper 2012). One interpretation of the variation in results between studies is the importance of context in behaviour change, and measuring behaviour alone does not provide insight into the complexities of how the school environment influences behaviour change.

Studies conducted under this research question represent several contributions to knowledge. This study supports existing evidence that the school environment has an impact on health and well-being within childhood (Viner et al. 2012), and extends previous research as the first longitudinal cohort study following children from primary to secondary school to explore the impact of a change of school environment on multiple obesity-risk behaviours. More specifically, this was the first study to demonstrate the impact on screen time and dietary behaviour over the transition from primary to secondary school. It was also a
first to compare student cohorts by their change of school status, providing
evidence of the magnitude that the disruptive shift of environment had on
particular behaviour. The next stage of the research, for an understanding of the
importance of context on behaviour change, was to explore whether differences
in PA and food environments between primary and secondary school provide
further insight for changes in behaviour over this period.

9.2.3 RQ3. What are the differences between primary & secondary school
contexts in relation to children’s PA & food environments?

Findings related to this research question supported the hypothesis that
differences in school PA and food environments between primary and secondary
school have the potential to influence children’s eating and physical activity
behaviours. This study extended the work under the previous research
questions. Paper 1 identified some differences between school PA/screen
environments that were both potentially encouraging (e.g., most secondary
schools having existing electronic device policies that restrict the use of leisure
screen time during school hours), and discouraging (e.g., students perceiving less
encouragement to engage in PA at school lunch breaks, and less time and
resources available for PA outside of class-time at secondary compared to
primary school). The secondary school food environment was identified in paper
2 as being potentially less conducive for healthy eating compared to primary
school. For example, a lower proportion of secondary schools (in comparison to
primary schools), had a healthy canteen/food policy. School canteen/food
services also operated on more school days at secondary than at surveyed
primary schools. Whilst these results may be indicative of the sampled
secondary schools, response rates were generally lower from secondary schools
as compared to primary schools, and as such, these results should be interpreted
with caution.
Existing evidence highlights the potential for school environment interventions to increase PA (e.g., improving PA facilities), yet there is less evidence for improvement in healthy eating (de Vet, de Ridder & de Wit 2011). The need for interventions to modify the school environment and create a culture to support healthy eating and being active throughout childhood for targeting obesity and/or obesogenic behaviours is recognised (Bonell et al. 2013; Story, Nanney & Schwartz 2009; Summerbell et al. 2005; Waters et al. 2011). There is also little evidence of differences in PA and food environments between school types, with interventions predominately based in either the primary or secondary school setting. One recent study researching PA environments across the primary to secondary school divide, found that changes to the school PA environment (e.g., promoting active schoolyards and health education policies) predict an increase in PA from primary to secondary school (De Meester et al. 2014). In relation to the school food environment, a recent systematic review of primary, middle and secondary school food environment interventions found that modifying the food environment (e.g., food policy and marketing) has a positive effect on student dietary intake and/or BMI status (Driessen et al. 2014). This review also highlighted the importance of instilling healthy eating habits prior to the secondary school years. Findings from TranSFORM adds to this work by providing evidence of differences between school contexts where intervention has the potential to promote continuity of PA and healthy eating over the school transition.

Whilst the current study found potential for differences in PA and food environments between school types to impact behaviour, evidence was insufficient to make any direct association between the impact from a difference in school environment between primary and secondary school (e.g., less time for recess at secondary compared to primary school to provide PA opportunities), and behaviour change. Results of research questions 1-2 identified that a change of school environment impacts obesogenic behaviour, whilst research question 3 identified the potential of the physical environment to affect behaviour. Given the increasing importance of peers from late childhood and into adolescence
Brown 2004), the next stage of the TranSFORM study was to explore whether a change in the social environment was a factor in behaviour change as students transitioned from primary to secondary school.

9.2.4 RQ4. Are friendship networks associated with a change in obesogenic behaviour?

Findings of this study are consistent with the hypothesis that characteristics of personal networks in late childhood and early adolescence are predictive of changes in PA, sedentary and dietary behaviour. Paper 3 demonstrated that various personal network characteristics were associated with PA and sedentary behaviour in late childhood. Paper 4 demonstrated that particular personal network characteristics are also predictive of a change of behaviour from late childhood into adolescence, and that characteristics of networks in late childhood can have lasting effects for positively engaging in PA at a later time. As shown in paper 3 and 4, these associations generally differed by gender.

That different personal network characteristics were found associated with PA and sedentary behaviour in late childhood compared to characteristics that predicted a change in PA and sedentary behaviour over time, suggests contextual differences in social influence mechanisms. Having very active friends was found to be positively associated with MVPA and negatively associated with sedentary/screen time in late childhood, but an increase in the proportion of very active friends over time did not predict the same direction of behaviour (i.e., for males, an increase in the proportion of very active friends between primary and secondary school was predictive of a decrease in MVPA over time). Similarly, Jago et al. (2011) found activity levels to be positively associated between pre-adolescent best friends in late primary school, yet further research showed that an increase in MVPA for girls was positively associated with the number of friends over the school transition (Jago, Page & Cooper 2012). It could be that normative behaviour of being ‘very active’ amongst peers holds
prominence in late primary school, whereas other network mechanisms are more influential in promoting an increase in PA behaviour over time.

That different personal network characteristics generally differed by gender for predicting behavioural change, is consistent with existing social network research in relation to PA, sedentary (Sawka et al. 2013) and dietary behaviour (Sawka et al. 2015). For boys, having more friends and a high proportion of male friends were important network characteristics for increased PA, whilst playing sport with friends was associated with a decline in the consumption of non-core foods. These factors suggest group PA participation is critical for maintaining/increasing PA levels in early adolescent males, and that this can also have a positive influence on dietary intake. No network characteristics predicted a change in screen time for boys.

For girls, network stability predicted increased poor dietary intake, whilst having more friends was predictive of increased screen time. Promoting a reduction in screen time and inactivity is a potential challenge, given that girls continue to increase time spent on social media through to adolescence (Houghton et al. 2015). This is further compounded when having more friends not only increases screen time, but provides more friends for which to engage in social media with. Paper 4 also demonstrated that having a high proportion of friends to play sport with in late childhood was predictive of engaging in more MVPA over time, particularly for girls. Existing longitudinal evidence show evolution of networks, through the selection of friends with similar behaviour and adoption of behaviour over time (de la Haye et al. 2011b). The current study furthers this work on the impact of friendship networks, by revealing lasting network effects in late childhood on behaviour, and demonstrating that earlier behavioural habits can endure through environmental (physical and social) change. This finding emphasises the importance of reinforcing behaviour, in particular PA engagement for girls, in late childhood to promote PA into adolescence.
To summarise, studies conducted under this research question represent several contributions to knowledge. This was the first study to explore the impact of a change of school environment and peer influence across the primary to secondary school transition on multiple obesity risk behaviours, identifying the importance of different contexts, network characteristics and mechanisms that positively and negatively influence behaviour. These findings provide further understanding of the nuances of social network characteristics that influence PA, sedentary and (to a lesser extent) dietary behaviour, and reinforce the need for customising gender specific behavioural interventions.

9.2.5 Influences on school break PA intensity model

For a consolidated depiction of identified influences on behaviour within the study sample, results for one behaviour are presented within a visual model (Figure 11). The behaviour modelled, PA intensity at school breaks (recess and/or lunch), was selected to illustrate a range of identified (i.e., transition to different school environment; friendship characteristics) and potential (i.e., school PA environment) influences, positive and negative, visualised together.
This model portrays the shift of school having a detrimental effect on PA intensity following the transition to secondary school, and notes differences in school PA environments (e.g., less time allocated for recess at secondary compared to primary school) which may contribute to this effect. The model also incorporates various network friendship characteristics (e.g., more friends being predictive of higher PA intensity for males at secondary school) having positive effects on PA intensity during school breaks.
Identifying opposing influences demonstrates the importance for understanding behaviour and potential behaviour change from a systems perspective, where a system (e.g., in relation to obesity) is defined as the interrelationship of individual, social and environmental factors functioning as a whole to impact upon behaviour that contributes to obesity (Foster-Fishman, Nowell & Huilan 2007; Huang et al. 2009). Particularly when the sample model pictured here represents just one of multiple PA behavioural aspects. It is therefore imperative that any obesity prevention intervention attempt to address behaviour change is mindful of such dynamics, including how social networks can mediate behaviour change (Hunter et al. 2015), and reinforces the need to tailor intervention by context (and gender) to maximise effectiveness.

9.3 Study strengths and limitations

The following is an overview of strengths and limitations of the study as a whole, which have previously been discussed within each relevant paper with specific reference to each study. The main strengths of the study were the longitudinal cohort design, a very high retention rate of participants across the primary to secondary school transition in both school-type student cohorts, and the independence of schools at baseline. Limitations included self-reported behaviour, relatively low response rates within some schools, lack of availability to allocate accelerometers to all students at T2 (thereby limiting objective PA data), and potentially limited generalisability of results, as previously discussed within results papers. For example, a validation study has shown a tendency for under-reporting time spent in PA using the CLASS self-report survey (Telford et al. 2004). However due to the TranSFORM longitudinal study design using the same survey by the same participants at two time points, this limitation is minimised (i.e., comparison of results from the two sets of data, even if consistently underreported, is able to identify a difference in PA behaviour, a principal study aim).
Further limitations were in relation to opt-in consent and school staff selection. Opt-in consent requires each student to provide written parental consent for study participation. The resulting relatively low response rates in some schools not only introduced risk of participant bias as previously discussed, but also limited the ability to conduct complete network analyses. Response rates within this study are comparable of other studies within Australian schools requiring opt-in parental consent (Allender et al. 2011; Liong, Ridgers & Barnett 2015), where participation rates within lower SES regions have been as low as 10% (Lombard et al. 2010). As outlined within the methods chapter, the selection of staff for participation within the school survey was made by the school contact person, not the researcher. Whilst this potentially introduces reporting bias should the participants be selected by their expected survey responses (whether positive or negative), this was not evident as shown in the variation in responses reported at each school.

In addition, the study was conducted in two phases only. Whilst this design was appropriate to address study aims, a third phase would have provided further insight of social mechanisms on behaviour as friendships continue to evolve in adolescence. Of the dearth in current social network research on obesogenic behaviour in childhood and adolescence, there is minimal longitudinal evidence and few are grounded in social development theory towards understanding potential social mechanisms of influence on behaviours (Sawka et al. 2013). These aspects were further strengths of the current study.

9.4 Implications for policy and practice

The key findings from this study, i.e., the impact of the school transition, the importance of context (e.g., within/outside of school, school type), and the significance of friendship networks on obesity risk behaviour, have implications for policy makers and practitioners. That a shift of school has mostly a detrimental effect on health related behaviour above and beyond the effect of
transition from one year level to another demonstrates the importance for schools to have consistency of policy and supportive environments for promoting and reinforcing healthy weight behaviour throughout the primary and secondary years of schooling. Consistent with the WHO health promoting school framework to strengthen school capacity by incorporating healthy school policy, physical and social environments for improving the health of the school community (Department of Human Services 2000; World Health Organization 2015c), supportive environments for healthy weight behaviour must also be maintained and reinforced as students transition between school types. For example, consistency of healthy canteen/food and personal electronic device policies, and providing supportive environments to promote and encourage PA (e.g., provision of sporting equipment within school breaks) at primary, middle and secondary schools.

The TranSFORM study observed differential effects of behavioural contexts and network characteristics for engaging in types of PA, sedentary (and some) dietary behaviour. The value of these findings have implications for intervention efforts to promote positive healthy weight behaviour in adolescence. The complexity of obesity calls for a bottom-up in addition to a top-down policy approach to prevention (Huang, Grimm & Hammond 2011), yet a challenge is to understand and identify context-specific influences on behaviour for informing and leveraging intervention. An understanding of the role of friendship networks and identifying which social mechanisms are influential on behaviour identified within this thesis, could be used to enhance existing and future intervention design by incorporating peer influence to facilitate desired healthy weight behaviour throughout childhood and adolescence. For example, reinforcing normative behaviour of being active in late childhood by encouraging involvement in sporting groups amongst peers, may have lasting effects that lead to increased PA in early adolescence. These findings demonstrate the potential role that social networks can play in the maintenance of healthy behaviour and behaviour change within late childhood and adolescence. Future intervention should look at ways to integrate inactive pre-adolescent children...
into existing active peer groups (for example), and identify potential school/program structures that help promote healthy normative behaviours amongst peer groups at both the primary and secondary school level. This would need to entail a whole of school approach, particularly at a secondary school level where new networks are formed, to facilitate diffusion of healthy behaviour norms. For example, identify individuals/groups of later year students as peer role models for harnessing network behaviour to promote healthy normative behaviours with students entering the secondary school environment. A similar approach has been successfully implemented within a number of Australian secondary schools, where year 10 students become peer educators for promoting healthy lifestyles with year 8 students (Shah et al. 2016).”

That social influence mechanisms differ by age, gender and behaviour demonstrates the importance of being cognisant of, and responsive to, the need for tailoring intervention by network context. For example, within the context of sport participation amongst male peers having a positive effect of reducing non-core food consumption, interventions aimed at improving dietary intake in males could also consider sporting involvement for more effective outcomes. Identification of social mechanisms on particular behaviours also creates challenges for public health efforts. For example, how to harness peer influence of adolescent girls to challenge and modify behavioural norms to reduce excessive screen time. An effective strategy may be to exploit female online friendship networks to encourage and promote PA and a reduction in screen time amongst the peer group. The dynamics of the peer environment can also have positive spill over effects, as found in an intervention with overweight children and adolescents that showed improvement in weight both within participants and their peers (Quinto Romani 2014). Yet not all peer interventions successfully improve multiple behaviour, as shown in a school based peer education program that was effective in reducing screen time, but not successful in increasing PA in a sample of students (Cui et al. 2012). This further demonstrates the importance of having an understanding of the context and mechanisms of peer influence for targeting behaviour change. Traditional study
designs/methods are not appropriate for exploring the complex nature of networks, where behaviour of a system of interacting individuals adapts to changing circumstances (Luke & Stamatakis 2012). The social network methodology employed within this study, as a method for identifying complex mechanisms for targeting intervention, would be recommended not only as a valuable tool for intervention design, but also for evaluation of intervention effectiveness (Mabry et al. 2010).

9.5 Unanswered questions and future research

This study included an assessment of the school PA and food environment by school type (primary/secondary) to understand the contexts that students were exposed to as they transitioned from primary to secondary school. Further exploration of school capacity to provide a broader understanding of the culture and climate in relation to school attitudes, knowledge and resourcing regarding childhood obesity within the school community would assist in informing school-based obesity prevention efforts. School capacity data was collected from school staff within the existing study using a community readiness tool to assess awareness and preparedness (Plested, Edwards & Jumper-Thurman 2006) for obesity prevention within schools, that has successfully been used elsewhere (Bell et al. 2008; Frerichs et al. 2012; Millar et al. 2013). Analysis of this data (which is currently in progress at the time of thesis submission) will give insight into areas for potential intervention, whilst reporting results back to schools is a step towards understanding whether childhood obesity is an issue to be addressed within their school community.

This research conducted quantitative analyses on the impact of a change of school environment on obesity related behaviour in childhood and adolescence. A future recommendation to gain further insight of mechanisms of behaviour change over this period, recognising the complexity of influences on behaviour from a disruptive change of school environment, would be to conduct qualitative
analyses of perspectives from participants undergoing the school transition. One suggested approach is the use of group model building, a participatory problem conceptualisation workshop method for understanding causes, influences and impacts on behaviours of interest (Hovmand et al. 2012). Such an approach is recommended to help further identify potential leverage points (e.g., contexts, networks) for encouraging healthy weight behaviour. This evidence would be recommended for use in the design of evidence-based models for effective intervention (Hovmand 2014; Zhang et al. 2015) targeting obesogenic behaviours in adolescence.

This study assessed the impact on behaviour over the disruptive change of school and social environment between primary and secondary school, revealing friendship network characteristics that predict behaviour change over this time. It is likely that friends continue to influence behaviour development, as friendships evolve over the later school years. Given the decline in PA and dietary behaviour, and increase in sedentary behaviour during the course of adolescence (NSW Government 2011), a longer study period is needed to further explore and understand the impact of social networks on behaviour and weight status. Untested research questions include whether the stability of longer term friendship networks has a moderating influence on behaviour in later adolescence; and whether these effects on behaviour are experienced within the immediate school environment, or outside of school hours. For example, a longitudinal study over a two year period found a decline in weekday MVPA but increase in PA outside of school hours (De Meester et al. 2014). Further evidence is also needed for understanding the longer term influence on dietary and sedentary behaviours.

Within this study two further research areas were identified. Firstly, limited responses from school staff within the TranSFORM study did not allow direct associations to be made between the school environment and student behaviour (as mentioned in RQ3 discussion above). Recognising the significance that a change of school physical and social environment can have on obesogenic
behaviour in adolescence, a more detailed investigation to identify potential areas to intervene (e.g., within primary and/or secondary school canteen/food services) to promote healthy weight behaviour across the school transition is needed. Secondly, given the critical role that social networks are likely to play in the future of obesity prevention (Li et al. 2012), findings from TranSFORM and similar research are important to utilise. Evidence of mechanisms (e.g., impact of normative influence of having very active friends in late childhood on individual PA) relevant per context must be considered and incorporated into the design, implementation and evaluation of existing and future behaviour change interventions to promote healthy weight behaviour in adolescence.
Chapter 10 Conclusion

In summary, TranSFORM explored the impact a shift of school environment and influence of friendship networks on obesogenic behaviour in late childhood and early adolescence, providing important evidence of mechanisms affecting behaviour change at this critical life stage. Study findings that the school transition has an impact (albeit mostly detrimental) on behaviour in early adolescence demonstrates that obesogenic behaviours are amenable to change from modifications to the school environment (physical and social), which importantly, has an overall effect on these behaviours, both within and external to the school environment. These results provide strong evidence of the influence of friendship networks, both for behaviour change, and for the potential to reinforce behaviour norms to promote positive weight related behaviour. Within the current climate where childhood obesity prevalence is relatively high and obesity prevention is an international priority, TranSFORM results identifying contextual friendship influences on obesity risk behaviour provides valuable evidence for informing behaviour change intervention design that harness the influence of adolescent social networks. Given the complexity and dynamic problem of obesity, an understanding of contextual nuances of peer influence on behaviour cannot be ignored.
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In addition to the following list, further references are contained within each results paper.


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Appendices

Appendix A  Ethics approvals

A1  Deakin University
A2  Department of Education and Early Childhood Development
A3  Archdiocese of Melbourne
A4  Diocese of Ballarat
A5  Diocese of Sale
A6  Sandhurst Catholic Education Office
Memorandum

To: Dr Lisa Barnett
   School of Health & Social Development

cc: Mrs Jennifer Faye Marks

From: Deakin University Human Research Ethics Committee (DUHREC)

Date: 16 May, 2013

Subject: 2013-093

Friends and health behaviour over the primary to secondary school transition

Please quote this project number in all future communications

The application for this project was considered at the DU-HREC meeting held on 13/05/2013.

Approval has been given for Mrs Jennifer Faye Marks, under the supervision of Dr Lisa Barnett, School of Health & Social Development, to undertake this project from 16/05/2013 to 16/05/2017.

The approval given by the Deakin University Human Research Ethics Committee is given only for the project and for the period as stated in the approval. It is your responsibility to contact the Human Research Ethics Unit immediately should any of the following occur:

- Serious or unexpected adverse effects on the participants
- Any proposed changes in the protocol, including extensions of time.
- Any events which might affect the continuing ethical acceptability of the project.
- The project is discontinued before the expected date of completion.
- Modifications are requested by other HRECs.

In addition you will be required to report on the progress of your project at least once every year and at the conclusion of the project. Failure to report as required will result in suspension of your approval to proceed with the project.

DUHREC may need to audit this project as part of the requirements for monitoring set out in the National Statement on Ethical Conduct in Human Research (2007).

Human Research Ethics Unit
research-ethics@deakin.edu.au
Telephone: 03 9251 7123
2013_001992

Mrs Jennifer Marks
WHO Collaborating Centre for Obesity Prevention
Population Health Strategic Research Centre
Faculty of Health
Deakin University
Locked Bag 20000
GEELONG 3220

Dear Mrs Marks

Thank you for your application of 2 May 2013 in which you request permission to conduct research in Victorian government schools and/or early childhood settings titled *Friends and health behaviour over the primary to secondary school transition*.

I am pleased to advise that on the basis of the information you have provided your research proposal is approved in principle subject to the conditions detailed below.

1. The research is conducted in accordance with the final documentation you provided to the Department of Education and Early Childhood Development.

2. Separate approval for the research needs to be sought from school principals and/or centre directors. This is to be supported by the DEECD approved documentation and, if applicable, the letter of approval from a relevant and formally constituted Human Research Ethics Committee.

3. The project is commenced within 12 months of this approval letter and any extensions or variations to your study, including those requested by an ethics committee must be submitted to the Department of Education and Early Childhood Development for its consideration before you proceed.

4. As a matter of courtesy, you advise the relevant Regional Director of the schools or governing body of the early childhood settings that you intend to approach. An outline of your research and a copy of this letter should be provided to the Regional Director or governing body.

5. You acknowledge the support of the Department of Education and Early Childhood Development in any publications arising from the research.

6. The Research Agreement conditions, which include the reporting requirements at the conclusion of your study, are upheld. A reminder will be sent for reports not submitted by the study’s indicative completion date.
7. If DEECD has commissioned you to undertake this research, the responsible Branch/Division will need to approve any material you provide for publication on the Department’s Research Register.

I wish you well with your research study. Should you have further enquiries on this matter, please contact Youla Michaels, Project Support Officer, Research, Evaluation and Analytics Branch, by telephone on (03) 9637 2707 or by email at michael.youla.edumail.vic.gov.au.

Yours sincerely

Joyce Cleary
Director
Research, Evaluation and Analytics Branch

20/06/2013

enc
Dear Mrs Marks

I am writing with regard to your research application received on 17 June 2013 concerning your forthcoming project titled ‘Friends and health behaviour over the primary to secondary school transition’. You have asked approval to involve a Catholic school in the Archdiocese of Melbourne, as you wish to involve students.

I am pleased to advise that your research proposal is approved in principle subject to the eight standard conditions outlined below.

1. The decision as to whether or not research can proceed in a school rests with the school's principal, so you will need to obtain approval directly from the principal of the school that you wish to involve.

2. You should provide the principal with an outline of your research proposal and indicate what will be asked of the school. A copy of this letter of approval, and a copy of notification of approval from the organisations/university's Ethics Committee, should also be provided.

3. A Working with Children (WWC) check – or registration with the Victorian Institute of Teaching (VIT) – is necessary for all researchers visiting schools. Appropriate documentation must be shown to the principal before starting the research in the school.

4. No student is to participate in the research study unless s/he is willing to do so and informed consent is given in writing by a parent/guardian.
5. Any substantial modifications to the research proposal, or additional research involving use of the data collected, will require a further research approval submission to this Office.

6. Data relating to individuals or the school are to remain confidential.

7. Since participating schools have an interest in research findings, you should consider ways in which the results of the study could be made available for the benefit of the school community.

8. At the conclusion of the study, a copy or summary of the research findings should be forwarded to the Catholic Education Office Melbourne. It would be appreciated if you could submit your report in an electronic format using the email address provided below.

I wish you well with your research study. If you have any queries concerning this matter, please contact Ms Lisa Guerin of this Office.

The email address is <km@ceomelb.catholic.edu.au>.

Yours sincerely

Cecille Jeffery
ACTING MANAGER, POLICY & RESEARCH
17 June 2013

Mrs Jennifer Marks
WHO Collaborating Centre for Obesity Prevention
Health Strategic Research Centre, Faculty of Health
221 Burwood Hwy
BURWOOD 3125

Dear Jennifer

I am in receipt of your application requesting the participation of Catholic schools in the Diocese of Ballarat in your Research Project: *Friends and health behaviour over the primary to secondary school transition*

I am pleased to advise that on the basis of information you have provided I grant permission for you to approach the Principals of our schools seeking their involvement in the project. You will understand that many requests are made to our schools and I am conscious of the time commitment required by participants. With this in mind I stress that the decision as to whether or not to participate rests with the individual Principals.

The following **general conditions** apply to all persons/institutions conducting research in schools in the Diocese of Ballarat:

1) The decision as to whether or not your research can proceed in a school rests with the School Principal. For each school in which you wish to do the research, you must obtain approval directly from the School Principal.

2) You are requested to provide the Principal with an outline of your research proposal and the likely time that participation in the research project will demand. A copy of notification of approval from the appropriate Ethics Committee should also be provided to the participating school.

3) A Criminal Record check is necessary for all researchers visiting schools and should be shown to the Principal before starting research in each school.

4) No student is to participate in your research study unless s/he is willing to do so and permission is given by a parent/guardian. Sufficient information must be provided to enable a parent/guardian to make an informed decision. Permission to participate would generally be indicated by means of a consent form, signed by a parent/guardian and returned to the school. You are requested to liaison with the School Principal to assist in the writing of a letter to parents/guardians regarding information about the research project.

5) You are requested to forward a list of schools/participants to this office.

6) Any substantive modifications to the research proposal or additional research involving use of the data collected will require a further research approval submission to this office.

7) Data relating to individual students or schools is to remain confidential.

8) I will look forward to receiving a copy of the research findings and would expect that you offer such results to participating schools.

I take this opportunity to wish you success with your research project.

Yours sincerely

Audrey Brown
DIRECTOR.

ABN. 45 567 853 964
PO Box 576 Ballarat Victoria 3353
Tel. (03) 5337 7135 Fax. (03) 5331 5166 Email: director@ceoballarat.catholic.edu.au

www.ceoballarat.catholic.edu.au
5 July, 2013

Mrs Jennifer Marks
Deakin University
Health Strategic Research Centre
Faculty of Health
221 Burwood Highway
BURWOOD VIC 3125

Dear Mrs Marks,

Thank you for your correspondence dated 14 June, 2013 in which you have submitted documents to conduct research entitled “Friends and health behaviour over the primary to secondary school transition” in secondary schools in the Diocese of Sale.

Whilst I am happy for you to approach secondary schools in this diocese as indicated in your application, I do not give permission for you to distribute inducements to participating schools. Consequently I request that any reference to this practice is removed from documents before they are distributed to Catholic schools in the Diocese of Sale. It is important that you understand that the final permission for you to undertake this work rests with the Principal.

This in principle approval is subject to the attached Research in Catholic Schools – Standard Conditions.

Should you require further information please contact Mrs Pauline Low at this Office, by email plow@ceosale.catholic.edu.au or phone 5622 6634.

With best wishes

Yours sincerely

Signature Redacted by Library

Maria Kirkwood
DIRECTOR OF CATHOLIC EDUCATION
DIOCESE OF SALE

Faith ... Learning ... Growth
RESEARCH IN CATHOLIC SCHOOLS – STANDARD CONDITIONS

This *in principle* approval is subject to certain standard conditions:

1. The decision as to whether or not a project can proceed in a school rests with the school principal. You will need to obtain approval directly from the principal of each school that you wish to involve.

2. You should provide the principal with:
   - a Plain Language Statement (PLS) for the principal describing the research;
   - documents to be used in the project e.g. PLS for participants/parents, consent forms etc;
   - a copy of the Catholic Education Office letter of approval which may include conditions placed on the approval;
   - a copy of notification of Ethics Committee approval, if applicable.

3. Consent from principals, parents and participants must be sought through an 'opt in' basis.

4. If your study involves one-to-one contact with a child, you are required to provide the principal with a certified copy of your registration with the Victorian Institute of Teaching or a current *Working with Children Check*.

5. You should provide to the Director of this Office, a list of schools which have agreed to participate in the research project.

6. Any substantive modifications to the research proposal or additional research involving use of the data collected will require a further research approval submission to this Office.

7. Data relating to individuals or schools is to remain confidential.

8. The collection and use of information from schools must conform with the Privacy Amendment (Private Sector) Act 2000 as indicated in the School's Privacy Policy.

9. Since participating schools have an interest in the findings, you should discuss with each principal ways in which the results of the study could be made available for the benefit of the school community.

10. At the conclusion of the study, a copy of the summary of the findings should be forwarded to the Director of this Office.
27 June 2013

Ms Jennifer Marks
WHO Collaborating Centre for Obesity Prevention
Deakin University School of Health & Social Development
Faculty of Health
221 Burwood Hwy
BURWOOD 3125

Dear Jennifer

Friends and health behaviour over the primary to secondary school transition

I am pleased to advise that, in relation to schools in the Diocese of Sandhurst, your research proposal is approved subject to the following standard conditions:

1. The decision as to whether or not research can proceed in a school rests with the Principal of that school. You will therefore need to obtain approval directly from the Principal of each school that you wish to involve.

2. You should provide each Principal with an outline of your research proposal and indicate what will be asked of the school. A copy of this letter of approval and a copy of the notification of approval from the relevant Ethics Committee should also be included.

3. No student is to participate in research study unless s/he is willing to do so and informed consent is given by a parent/guardian.

4. You should provide a list of schools which have agreed to participate in the research project to the Professional Development section of this Office.

5. Any substantive modifications to the research proposal, or additional research using the data collected, will require a further research proposal approval submission to this Office.

6. Data relating to individuals or schools is to remain confidential.

7. Since participating schools have an interest in the research findings, you should discuss with each Principal ways in which the results of the study could be made available for the benefit of the school community.

8. At the conclusion of the study a copy of the research findings should be forwarded to

Catholic Education Office, Sandhurst
Attn: Assistant Director, Research, Policy & Governance

(Note: should the research be carried out over more than one year, a progress report is required each December)

I wish you well with your research study. If you have any queries concerning this matter, please contact Rosemary Rasmussen (Tel: 5443 2377) of this Office.

Yours sincerely,

Brenda Keenan
Assistant Director, Research, Policy & Governance
Appendix B  Recruitment

B1  School letter of invitation
B2  School plain language statement and consent form
B3  Parent plain language statement and consent form
B4  Student plain language statement
B5  Parent/student invitation letter
Date

Address & school contact details

Dear,

**Name of school** is invited to participate within a research study conducted by Deakin University entitled: “*Friends and health behaviour over the primary to secondary school transition*”. The aim of the study is to understand how primary and secondary schools influence healthy eating and physical activity in children.

It is anticipated this project will benefit school personnel by increasing awareness of the impact that school systems have on student’s healthy eating and physical activity behaviour. Results of this study will be used for looking at how friendship groups can be used to promote healthy eating and physical activity within schools.

Please find attached a Plain Language Statement providing an overview of the project and what it involves. This research is being conducted by a PhD student researcher under the supervision of Dr Lisa Barnett, and as such will be regularly monitored throughout and conducted with professionalism and respect for all participants. The researcher will work with the school to arrange timing of data collection to minimise disruption to classes, as well as respect sensitivities of privacy and confidentiality associated with taking student height, weight and waist measurements.

Please complete the attached organisational consent form if you would like your school to take part in this research and return to the address below or by return email. Should you have any questions, please feel free to contact myself, details below.

Yours sincerely,

Jennifer Marks
WHO Collaborating Centre for Obesity Prevention
Population Health SRC
Deakin University
221 Burwood Highway
Burwood VIC 3125
Telephone: 03 9244 6258
Fax: 03 9244 6624
Email: mjenn@deakin.edu.au
XXX primary school is invited to take part in this research project being conducted in Victorian primary and secondary schools. Participation in any research project is voluntary. If you do not wish to take part you are not obliged to. Deciding not to participate will not affect your relationship to the researchers or to Deakin University. This is a longitudinal study with students over the period from year 6 primary school to year 7 secondary school. Schools will be selected for study participation where both primary and corresponding secondary schools consent. Once you have read this form and agree to participate, please sign the attached consent form on behalf of your school. You will be provided with a copy of this Plain Language Statement.

**Background and purpose**
Childhood obesity is a major concern in Australia because it often leads to obesity later in life. Obesity in adulthood can cause health problems such as Type 2 diabetes, heart disease, depression and stroke. Preventing obesity can start in childhood by eating healthy food and getting enough exercise. Moving from primary to secondary school means children may change what they eat and how much exercise they get. They may also change their friends and copy what their friends do.

The aim of this study is to understand how primary and secondary schools might affect eating and exercise in children. This means understanding whether students change their
eating and exercise between their last year of primary school (grade 6) and their first year of secondary school (year 7).

Methods

Participation in this project will be conducted in primary schools in 2013 and in secondary schools in 2014 and involve school personnel and students. As the principal of a primary school, you will be asked to participate by completing a combined school environmental audit and community readiness survey. The questionnaire (with different sections) is also to be completed by the canteen manager, up to three school staff nominated by yourself, and a school committee representative. The school environmental audit section of the survey asks questions in relation to school physical activity and food environment policies and practices. The section to be completed by the school principal or nominee comprises 28 questions. An example of a survey question is: “are students allowed to drink water in the classroom during class time?” There are 12 questions for the canteen manager and 22 questions for school staff.

The community readiness section of the survey is the same for each participant, comprising 20 questions. Questions are designed for an understanding of where a school is situated in relation to the problem of childhood obesity. An example of a question is: “What type of information about obesity is available for your school community?

The combined survey is anticipated to take approximately 20-30 minutes, which may be completed at a time and place of your convenience. Alternatively the researcher is available to go through the questionnaire in person or as a phone contact for questions, as preferred by each individual. Should the questionnaire be conducted in person we would like to voice record the interview if the participant is in agreement. All participants will be asked to complete a consent form prior to completing the survey.

Student participation

Grade 6 students will also be invited to participate in this study by: completing a questionnaire about their eating, physical activity and screen-use behaviour; have their height, weight and waist measurements taken; and wear an accelerometer over a week for a measure of physical activity. The questionnaire also includes a social network section asking the students who their friends are and who they spend time with, within and after school. This is for an understanding of how friends influence behaviour. The questionnaire, measurements and accelerometer fitting will be completed within class at a time in term 3 that is convenient to the school. As participants of a cohort study, students will be asked to participate in the same way (questionnaires, measurements, accelerometers) the following
year when they are in their first year of secondary school, year 7. Comparisons of
behaviours and measurements between outcomes will be included in the results of the
study. To enable students to be contacted when in year 7, a question in the questionnaire
asks which secondary school the student is planning to attend. The researcher will confirm
intended school lists of participating grade 6 students with the school by the end of the year.
Parental/guardian consent will be required for each participating grade 6 student. These will
be issued to students by paper copy, and an electronic copy will be sent to parents by email
where appropriate.

Benefits and risks
There is a low risk of harm or discomfort to participants within this study.

This project will benefit school personnel by increasing awareness of the impact that school
systems have on student’s healthy eating and physical activity behaviour. School readiness
reports on engaging with the problem of obesity will be summarised and made available at
the completion of the project. These reports are a useful tool either as information only or
for use towards developing prevention strategies. Results of this study will be used for
looking at how friendship groups can be used to promote healthy eating and physical activity
within schools.

Privacy, confidentiality and results
Any information obtained in connection with this project that can identify you will remain
confidential. To comply with government requirements, all data will be stored securely for a
period of a minimum of 7 years after final publication. It will then be destroyed.

The results of this study will be made public through the publication of journal articles and
conference papers. They will also be included as part of a Deakin University student PhD
thesis, who will be supervised throughout the project. Results will also be presented to
community service providers, government organisations and academics. No individual or
specific school will be named in any publication, thesis or presentation. A summary of results
will be provided to the school which will be made available to participants upon request.

Funding
This research is funded by Deakin University. As a thank you for participation, we would like
to offer your school a contribution of $100 towards sporting equipment or resources as
determined by your school.

Withdrawal
You may of course decide to withdraw from the study at any time using the enclosed withdrawal form, at which point any information obtained will not be used. You are also free to withdraw your data. There are no implications upon withdrawing from the project.

**Complaints**
If you have any complaints about any aspect of the project, the way it is being conducted or any questions about your rights as a research participant, then you may contact:

The Manager, Research Integrity, Deakin University, 221 Burwood Highway, Burwood Victoria 3125, Telephone: 9251 7129, research-ethics@deakin.edu.au

Please quote project number **2013-093**.

If you require further information or if you have any problems concerning this project, you can contact the principal researcher, Dr Lisa Barnett, whose contact details are:

Dr Lisa Barnett  
School of Health & Social Development  
Faculty of Health  
Burwood Campus  
Deakin University  
Telephone: 03 9244 6177  
Email: lisa.barnett@deakin.edu.au
PLAIN LANGUAGE STATEMENT AND CONSENT FORM

TO: School Principal

Organisational Consent Form

(To be used by organisational Heads providing consent for staff/members/patrons to be involved in research)

Date: July 2013
Full Project Title: Friends and health behaviour over the primary to secondary school transition
Reference Number: 2013-093

I have read and I understand the attached Plain Language Statement.

I give my permission for staff of ........................................................................................................ (name of school) to participate in this project according to the conditions in the Plain Language Statement.

I have been given a copy of Plain Language Statement and Consent Form to keep.

The researcher has agreed not to reveal the participants’ identities and personal details if information about this project is published or presented in any public form.

I agree that

1. The institution/organisation MAY / MAY NOT be named in research publications or other publicity without prior agreement.

2. I / We DO / DO NOT require an opportunity to check the factual accuracy of the research findings related to the institution/organisation.

3. I / We EXPECT / DO NOT EXPECT to receive a copy of the research findings or publications.
Name of person giving consent (please print) …………………………………………………………………………………

Signature ……………………………………………………………………… Date ………………………………..

Please return to the address below or by return email to:

Jennifer Marks
WHO Collaborating Centre for Obesity Prevention
Population Health SRC
Deakin University
221 Burwood Highway
Burwood VIC 3125
PLAIN LANGUAGE STATEMENT AND CONSENT FORM

TO: School Principal

Withdrawal of Consent Form

(To be used for schools who wish to withdraw from the project)

Date: July 2013

Full Project Title: Friends and health behaviour over the primary to secondary school transition

Reference Number: 2013-093

I hereby wish to WITHDRAW my consent for …………………………………………………………………….…… (name of school) to participate in the above research project and understand that such withdrawal WILL NOT jeopardise my relationship with Deakin University.

Name of person withdrawing consent (please print) ………………………………………………………………….

Signature …………………………………………………………….……………………………… Date ……………………

Please mail or fax this form to:

Jennifer Marks
WHO Collaborating Centre for Obesity Prevention
Population Health SRC
Deakin University
221 Burwood Highway
Burwood VIC 3125
Fax: 03 9244 6624
TO: Parent/Guardian

Plain Language Statement

Date: October 2013
Full Project Title: Friends and health behaviour over the primary to secondary school transition
Principal Researcher: Dr Lisa Barnett
Student Researcher: Jennifer Marks
Associate Researcher(s): Professor Steven Allender

Your son/daughter is invited to take part in this research project being conducted in Victorian primary and secondary schools. Participation in any research project is voluntary. If you do not wish your child to take part you are not obliged to. Deciding not to participate will not affect your child’s relationship to the researchers or to Deakin University. Once you have read this form and agree for your child to participate, please sign the attached consent form. You will be provided with a copy of this Plain Language Statement.

Background and purpose
Childhood obesity is a major concern in Australia because it often leads to obesity later in life. Obesity in adulthood can cause health problems such as Type 2 diabetes, heart disease, depression and stroke. Preventing obesity can start in childhood by eating healthy food and getting enough exercise. Moving from primary to secondary school means children may change what they eat and how much exercise they get. They may also change their friends and copy what their friends do.

The aim of this study is to understand how primary and secondary schools might affect eating and exercise in children. This means understanding whether students change their eating and exercise between their last year of primary school (grade 6) and their first year of secondary school (year 7).
Methods

This study will be conducted in primary schools in 2013 and in secondary schools in 2014. Grade 6 students are invited to participate in this study by: completing a questionnaire about their eating, physical activity and screen-use; have their height, weight and waist measurements taken; and wear an accelerometer over a week for a measure of physical activity. An example of a question is: “What do you usually eat at recess at school?” with a list of options that the student can choose from to tick.

The questionnaire also asks who their friends are and who they spend time with (e.g. at recess, lunch). The questionnaire, measurements and accelerometer fitting will be completed within class at a time in term 3 that is convenient to the school. Students will also be asked to participate in the same way (questionnaires, measurements, accelerometers) next year when they are in their first year of secondary school, year 7. So students can be contacted when in year 7, we will ask in the survey which secondary school the student is planning to attend.

Benefits and risks

Children in this study may feel uncomfortable having their measurements taken. However we will be doing all measurements in a separate private part of the room with two researchers present.

This project will help the school by increasing awareness of the impact that school systems have on student’s healthy eating and physical activity behaviour. Results of this study will be used to see how friendship groups can help to promote healthy eating and physical activity within schools.

Privacy, confidentiality and results

Any information obtained in connection with this project that can identify you will remain confidential. All data will be stored securely for a period of a minimum of 7 years after final publication. It will then be destroyed.

The results of this study will be made public through the publication of journal articles and conference papers. They will also be included as part of a Deakin University student PhD thesis, who will be supervised throughout the project. Results will also be presented to community service providers, government organisations and academics. No individual or specific school will be named in any publication, thesis or presentation. A summary of results will be provided to the school which will be made available to participants upon request to the researcher.
Funding
This research is funded by Deakin University.

Withdrawal
You may of course decide to withdraw from the study at any time, at which point any information obtained will not be used. You are also free to withdraw your data. There are no implications upon withdrawing from the project. Your child may withdraw at any time verbally with the researcher. You may use the enclosed withdrawal form to withdraw your child from the study.

Complaints
If you have any complaints about any aspect of the project, the way it is being conducted or any questions about your rights as a research participant, then you may contact:

The Manager, Research Integrity, Deakin University, 221 Burwood Highway, Burwood Victoria 3125, Telephone: 9251 7129, research-ethics@deakin.edu.au

Please quote project number 2013-093.

If you require further information or if you have any problems concerning this project, you can contact the principal researcher, Dr Lisa Barnett, whose contact details are:

Dr Lisa Barnett
School of Health & Social Development
Faculty of Health
Burwood Campus
Deakin University
Telephone: 03 9244 6177
Email: lisa.barnett@deakin.edu.au
PLAIN LANGUAGE STATEMENT AND CONSENT FORM

TO: Parent/Guardian

Withdrawal of Consent Form

(To be used for participants who wish to withdraw from the project)

Date: October 2013

Full Project Title: Friends and health behaviour over the primary to secondary school transition

Reference Number: 2013-093

I hereby wish to WITHDRAW my consent for my child to participate in the above research project and understand that such withdrawal WILL NOT jeopardise my relationship with Deakin University.

Participant’s name (please print) …………………………………………………………………………………………

Name of school (please print) ……………………………………………………………………………………………

Name of parent/guardian (please print) …………………………………………………………………………………

Parent/Guardian Signature ……………………………………………………… Date …………………………………

Please mail or fax this form to:

Jennifer Marks
WHO Collaborating Centre for Obesity Prevention
Population Health SRC
Deakin University
221 Burwood Highway
Burwood VIC 3125
Fax: 03 9244 6624
Hello,

My name is Jennifer Marks.

I am a student at Deakin University.

I am doing a project about when children finish at primary school and go to secondary school.

I want to know whether going to secondary school makes a difference in what students eat at school and whether the amount of exercise changes or not when students are in year 7. I also want to know whether students change what they eat or how much exercise they do to be the same as their friends. I hope this will help me to understand more about why we might change some of the things we do when we go to secondary school.

I would like you and the other students in your class to be to be part of my project.

If you agree I will give you a questionnaire for you to do in class with the other grade 6 students. The questions will be about the type of food you eat and the type of physical activity you do at school. There is also a question about who you hang out with the most at school.

I would also like to measure your height, weight and waist. This will also be done in class but will be private so no-one will see what your measurements are. After the measurement you will also get to wear an accelerometer around your waist. This is an electronic device that can measure your movements, such as walking and playing sport. This accelerometer needs to be worn for a week so we can measure different movement each day, but it needs to be taken off before bed and in the bath/pool/shower.
Because I would like to know the differences between primary and secondary school, I will also give you the same questionnaire and take your measurements when you are in year 7 of secondary school. There is a question in the questionnaire that you can write which secondary school you think you will be going to next year. This will help us to make sure we go to the right school when you are in year 7.

This project is voluntary, so you can do it or not, and you can change your mind about it later. You just have to tell me or your parents or teacher and we will take you out of the project. You won’t have to explain why.

If you don’t want to be in the project, you will continue with your class work as usual. If you feel worried about the project, or have any questions, you can talk to me, your parents or your teacher.

Thank you for thinking about helping me to find out more about changes that happen when you go to secondary school. If you are willing to take part, talk it over with your parents who will also have received a letter from me.

Yours sincerely,

[Signature Redacted by Library]

Jennifer Marks
WHO Collaborating Centre for Obesity Prevention
Population Health SRC
Burwood Campus
Deakin University
Telephone: 03 9244 6258
Email: mjenn@deakin.edu.au
Dear parent/guardian,

Deakin University is conducting a research program at name of school entitled: “Friends and health behaviour over the primary to secondary school transition”. The aim of the study is to understand how primary and secondary schools might affect healthy eating and physical activity in children.

As a grade 6 student, your son/daughter is invited to participate within this study along with all grade 6 students within the school. Participation in this research will be in 2013 (term 4) when your son/daughter is in grade 6, and again in 2014 (term 2) when your son/daughter is in year 7 secondary school. Participation at both stages will involve completion of a questionnaire; have height, weight and waist measurements taken; and wear an accelerometer over the period of one week. This is a small electronic device worn on a belt around the waist which measures physical activity movement.

This research is being undertaken by a PhD student researcher under the supervision of Dr Lisa Barnett, and will be conducted with professionalism and respect for all participants. The researcher will respect sensitivities of privacy and confidentiality associated with taking student height, weight and waist measurements. Measurements will not be taken if students feel uncomfortable in any way.

Further details are outlined in the attached Plain Language Statement. Please complete the attached (gold coloured) consent form if you would like your child to take part in this research and return in the enclosed envelope to the school with your son/daughter or to the box provided at the school office. Should you have any questions, please feel free to contact myself, details below.

Yours sincerely,

Signature Redacted by Library

Mrs Jennifer Marks
WHO Collaborating Centre for Obesity Prevention
Deakin University
221 Burwood Highway, Burwood VIC 3125
Telephone: 03 9244 6258
Fax: 03 9244 6624
Email: mjenn@deakin.edu.au
Appendix C  Surveys and data management

C1  School environment audit survey for school principal
C2  School environment audit survey for school teacher
C3  School environment audit survey for school canteen manager
C4  School capacity survey for addressing childhood obesity
C5  Anthropometric data record sheet
C6  Network data entry procedure
School Principal (or Senior Administrator)

School Environmental Audit & Readiness Capacity Survey

Schools can influence student’s nutrition and physical activity behaviours in many ways (policies, curriculum, role modelling, etc.). This survey is divided into two parts. Part 1 is an environmental audit to attain a picture of your schools policies and practices relating to nutrition and physical activity. Part 2 contains questions on community readiness capacity for understanding where schools are situated in relation to engaging with the problem of childhood obesity.

Instructions

The audit section has three sets of questions according to participant:

Survey 1 (this survey) is to be filled out by the Principal or a Senior Administrator. It is expected as part of this audit to attach copies of relevant policies or documents (where defined).

Survey 2 is to be filled out by the Canteen Manager or food service operator; and

Survey 3 is to be completed by at least 3 Teachers from your school.

Surveys 2 and 3 are not included in this document. The readiness capacity section of each survey is identical.

The survey will take approximately 30 minutes to complete per person. All parts of the survey are self-administered.

Answer the questions honestly; your answers will remain confidential. Where research related to this information is reported, your name and your school will not be identified.

Thank you for taking the time to complete this survey.

Please return the completed survey and signed consent form in the enclosed envelope to the school office in the box provided.

WHO Collaborating Centre for Obesity Prevention, Deakin University
Part 1: School Environmental Audit

To be completed by the Principal/Senior Administrator or other senior person who has access to school policy

School name: ____________________________________________

Type of school:  
- Primary school ☐ (1)  
- Combined Primary-Secondary school ☐ (2)  
- Secondary school ☐ (3)

Your name: ____________________________________________

Your phone number: ____________________________________  
(if needed for clarification of responses)

Date of completion of survey: ________________________________

What is your position?  
- Principal ☐ (1)  
- Deputy Principal/Senior Administrator ☐ (2)  
- Other ________________________________

Initials of survey administrator: ________________________________
The School Day

1. In the previous 12 months, what were the amounts of time (minutes) allocated for classes, lunch and recess during the school day? How many class periods are there on an average day?

<table>
<thead>
<tr>
<th>Time</th>
<th>Minutes per period</th>
<th>No. of class periods per day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Class time</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>Lunch time</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>Recess</td>
<td></td>
<td>N/A</td>
</tr>
</tbody>
</table>

Food Availability

2. In the previous 12 months, which student year levels were allowed to leave school grounds during the school day without special permission? Circle all year levels that apply appropriate to your school

Primary school students

- Prep
- Year 1
- Year 2
- Year 3
- Year 4
- Year 5
- Year 6

Secondary school students

- Year 7
- Year 8
- Year 9
- Year 10
- Year 11
- Year 12

No students permitted to leave (tick if applicable then go to question 4)

3. At what times during the day were the students permitted to leave the school grounds without special permission? Tick all that apply

- During lunch (1)
- During morning and afternoon recess (2)
- Other times (3)

How close is the nearest:

<table>
<thead>
<tr>
<th>Distance</th>
<th>Within 100 metres (1)</th>
<th>100m-500m (2)</th>
<th>500m-1km (3)</th>
<th>More than 1km (4)</th>
</tr>
</thead>
</table>

4. Milk bar or convenience store to your school? Tick closest option

5. Take-away/fast food outlet to your school? Tick closest option
### School Food Service

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>6</strong></td>
<td>In the last 12 months, was there a food service (e.g. canteen, lunch order system, breakfast club) operating at your school?</td>
<td><strong>Tick response</strong></td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>No (go to question 11)</td>
<td>(0)</td>
</tr>
</tbody>
</table>

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>7</strong></td>
<td>Who operated the food service?</td>
<td><strong>Tick response</strong></td>
</tr>
<tr>
<td></td>
<td>Canteen manager employed by the school (go to question 9)</td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>Volunteers (students, parents, etc.) coordinated by school staff (go to question 9)</td>
<td>(2)</td>
</tr>
<tr>
<td></td>
<td>External food company (e.g. local shop, food service organisation)</td>
<td>(3)</td>
</tr>
<tr>
<td></td>
<td>Other _____________________________________________</td>
<td>(4)</td>
</tr>
</tbody>
</table>

If an external food service company operated the school food service:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>8</strong></td>
<td>Was it covered by a written contract?</td>
<td><strong>Yes</strong> (1)  <strong>No</strong> (0)</td>
</tr>
</tbody>
</table>

If yes, is the contract up for renewal within 2 years?

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>9</strong></td>
<td>Was the school food service an important source of funds for the school?</td>
<td><strong>Yes</strong> (1)  <strong>No</strong> (0)</td>
</tr>
<tr>
<td><strong>10</strong></td>
<td>Did your school food service provider have a contract with a soft drink bottler or other food manufacturer giving the company exclusive rights or preference to sell soft drinks or other foods at your school?</td>
<td><strong>Tick response</strong></td>
</tr>
</tbody>
</table>

### Food and Nutrition

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>11</strong></td>
<td>At the beginning of 2013, did your school have a written policy (or policies) relating to promoting and supporting nutrition and healthy eating at school?</td>
<td><strong>Tick response</strong></td>
</tr>
<tr>
<td></td>
<td>Yes (please attach a copy/copies)</td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>No (go to question 13)</td>
<td>(0)</td>
</tr>
</tbody>
</table>
12. Did the policy (or policies) include:

<table>
<thead>
<tr>
<th>Yes (1)</th>
<th>No (0)</th>
</tr>
</thead>
<tbody>
<tr>
<td>What foods are available in the canteen?</td>
<td></td>
</tr>
<tr>
<td>The availability of drinking water for students?</td>
<td></td>
</tr>
<tr>
<td>Vending machines at school?</td>
<td></td>
</tr>
<tr>
<td>Foods used for fundraising?</td>
<td></td>
</tr>
<tr>
<td>Using food as a reward?</td>
<td></td>
</tr>
<tr>
<td>Food associated with school events? (e.g. sports days, parent evenings)</td>
<td></td>
</tr>
<tr>
<td>Teaching food and nutrition in the curriculum?</td>
<td></td>
</tr>
<tr>
<td>Staff acting as role models for healthy eating?</td>
<td></td>
</tr>
</tbody>
</table>

13. About how often in the last 12 months did your school give information to parents about healthy food and eating (at school events, in newsletters, etc.)? *If possible please attach some examples*

<table>
<thead>
<tr>
<th>Tick response</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 times (0)</td>
</tr>
<tr>
<td>1-3 times (1)</td>
</tr>
<tr>
<td>4-6 times (2)</td>
</tr>
<tr>
<td>7-10 times (3)</td>
</tr>
<tr>
<td>More than 10 times (4)</td>
</tr>
<tr>
<td>I don’t know (5)</td>
</tr>
</tbody>
</table>

14. About how often in the last 12 months did you have sporting, social or cultural events in your school sponsored by soft-drink, fast food or confectionary companies?

<table>
<thead>
<tr>
<th>Tick response</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 times (0)</td>
</tr>
<tr>
<td>1-3 times (1)</td>
</tr>
<tr>
<td>4-6 times (2)</td>
</tr>
<tr>
<td>7-10 times (3)</td>
</tr>
<tr>
<td>More than 10 times (4)</td>
</tr>
<tr>
<td>I don’t know (5)</td>
</tr>
</tbody>
</table>
In the last 12 months:

<table>
<thead>
<tr>
<th>Question</th>
<th>Yes</th>
<th>No</th>
<th>Not sure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Were students allowed to drink water in the classroom during class time?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Were students allowed to eat in the classroom during class time?</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Did your school have a school vegetable garden?</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Physical Education, Sports and Physical Activity

On average over the last 12 months, how many periods a week were devoted to formal physical education (PE) for the following year levels? If PE was not compulsory for a year level, please tick the box for either ‘Optional PE or equivalent’ or ‘No option for PE or equivalent’

<table>
<thead>
<tr>
<th>Year</th>
<th>Compulsory PE: number of periods per week</th>
<th>Optional PE or equivalent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prep</td>
<td></td>
<td>Optional (9)</td>
</tr>
<tr>
<td>Year 1</td>
<td></td>
<td>No option (99)</td>
</tr>
<tr>
<td>Year 2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 4</td>
<td></td>
<td></td>
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<tr>
<td>Year 5</td>
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<td>Year 6</td>
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<td>Year 7</td>
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<td>Year 8</td>
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<tr>
<td>Year 9</td>
<td></td>
<td></td>
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<tr>
<td>Year 10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 11</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Year 12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the last 12 months, did the school have a written policy/policies relating to promoting and supporting physical activity at school?

<table>
<thead>
<tr>
<th>Tick response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes (please attach copy/copies)</td>
</tr>
<tr>
<td>No (go to question 21)</td>
</tr>
</tbody>
</table>
20. Did the policy (or policies) include:

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>The use of school grounds ‘out of school hours’?</td>
<td>(1)</td>
</tr>
<tr>
<td>Providing access to sports equipment outside of formal sport or physical education?</td>
<td></td>
</tr>
<tr>
<td>Promoting cycling and/or walking to school?</td>
<td></td>
</tr>
<tr>
<td>Encouraging participation in sports or other active programs (e.g. Dance, aerobics)</td>
<td></td>
</tr>
</tbody>
</table>

21. On average, how often are the school grounds utilised by external clubs and other groups for supervised sports?

<table>
<thead>
<tr>
<th>Tick response</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 days a week</td>
</tr>
<tr>
<td>1 day a week</td>
</tr>
<tr>
<td>2 days a week</td>
</tr>
<tr>
<td>3 days a week</td>
</tr>
<tr>
<td>4 days a week</td>
</tr>
<tr>
<td>5 days a week</td>
</tr>
<tr>
<td>6 days a week</td>
</tr>
<tr>
<td>Every day of the week</td>
</tr>
</tbody>
</table>

22. Over the last 12 months, how many different clubs of community groups utilised the school grounds for sports and other recreational activities?

<table>
<thead>
<tr>
<th>Number of clubs/groups</th>
</tr>
</thead>
</table>

23. In the last 12 months:

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td>Could students access the school’s outdoor facilities at any time outside of school hours (i.e. weekends and holidays)?</td>
<td>(1)</td>
</tr>
<tr>
<td>Were there indoor facilities for physical activity (e.g. a gym, basketball court)?</td>
<td></td>
</tr>
</tbody>
</table>

24. Do most teachers participate in professional development / continuing education at least once a year?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>

25. Do staff have the opportunity for professional development training regarding the health benefits of nutrition and physical activity?

<table>
<thead>
<tr>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
</table>
## Personal electronic devices

**27** In the last 12 months, did the school have a written policy/policies relating to the use of personal electronic devices at school?  

<table>
<thead>
<tr>
<th>Yes (please attach copy/copies)</th>
<th>Tick response</th>
</tr>
</thead>
<tbody>
<tr>
<td>No (go to Part 2)</td>
<td></td>
</tr>
</tbody>
</table>

**28** Did the policy (or policies) include:  

<table>
<thead>
<tr>
<th>The use of hand held electronic games?</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(0)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>The use of school computers for personal use during school hours?</th>
<th>Yes</th>
<th>No</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(0)</td>
</tr>
</tbody>
</table>

End of Part 1. Part 2 starts on next page
School Teacher

School Environmental Audit & Readiness Capacity Survey

Schools can influence student’s nutrition and physical activity behaviours in many ways (policies, curriculum, role modelling, etc.). This survey is divided into two parts. Part 1 is an environmental audit and contains a number of personal ratings and judgements about the effectiveness of policies at your school. Part 2 contains questions on community readiness capacity for understanding where schools are situated in relation to engaging with the problem of childhood obesity.

Instructions

The audit section has three sets of questions according to participant:

Survey 1 is to be filled out by the Principal or a Senior Administrator;

Survey 2 is to be filled out by the Canteen Manager or food service operator; and

Survey 3 (this survey) is to be completed by at least 3 Teachers from your school.

Surveys 1 and 2 are not included in this document. The readiness capacity section of each survey is identical.

The survey will take approximately 30 minutes to complete per person. All parts of the survey are self-administered.

Answer the questions honestly; your answers will remain confidential. Where research related to this information is reported, your name and your school will not be identified.

Thank you for taking the time to complete this survey.

Please return the completed survey and signed consent form in the enclosed envelope to the school office in the box provided.
Part 1: School Environmental Audit

School name: ____________________________________________ □ □ □ □

Type of school:
- Primary school □ (1)
- Combined Primary-Secondary school □ (2)
- Secondary school □ (3)

Your name: _____________________________________________

Your phone number: ______________________________________
(if needed for clarification of responses)

Date of completion of survey: ____________________________

What is your position?
- Teacher □ (4)
- Please tick if Health or PE teacher □ (5)
- Other _________________________________

Initials of survey administrator: ____________________________

WHO Collaborating Centre for Obesity Prevention, Deakin University 2
### Food and Nutrition

1. Indicate your level of agreement/disagreement with the following statement: “In the previous 12 months, our school _canteen_ (food service) mainly provided foods with high nutritional value”

<table>
<thead>
<tr>
<th>Tick response</th>
<th>Strongly agree</th>
<th>Agree</th>
<th>Neither agree nor disagree</th>
<th>Disagree</th>
<th>Strongly disagree</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
</tr>
</tbody>
</table>

Questions 2, 3, and 4 relate to a written policy that promotes healthy eating

2. Does your school have a written school nutrition or healthy canteen policy?

<table>
<thead>
<tr>
<th>Tick response</th>
<th>Yes</th>
<th>No (if no, tick response and go to question 5)</th>
<th>Not sure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(1)</td>
<td>(0)</td>
<td>(99)</td>
</tr>
</tbody>
</table>

3. What proportion of _teachers_ and _parents_ do you think are aware of this policy? _Please tick one response for teachers and one response for parents._

<table>
<thead>
<tr>
<th>Teachers</th>
<th>Parents</th>
</tr>
</thead>
<tbody>
<tr>
<td>All or almost all</td>
<td>(1)</td>
</tr>
<tr>
<td>Most</td>
<td>(2)</td>
</tr>
<tr>
<td>About half</td>
<td>(3)</td>
</tr>
<tr>
<td>Some</td>
<td>(4)</td>
</tr>
<tr>
<td>Very few or none</td>
<td>(5)</td>
</tr>
</tbody>
</table>

4. How good was the school’s compliance with the school nutrition/healthy canteen policy in the last 12 months?

<table>
<thead>
<tr>
<th>Tick response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very good</td>
</tr>
<tr>
<td>Good</td>
</tr>
<tr>
<td>OK</td>
</tr>
<tr>
<td>Poor</td>
</tr>
<tr>
<td>Very poor</td>
</tr>
</tbody>
</table>
5. How would you rate the level of support for healthy eating provided by parents at your school in the last 12 months?  

<table>
<thead>
<tr>
<th>Ticket Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very high</td>
</tr>
<tr>
<td>High</td>
</tr>
<tr>
<td>Moderate</td>
</tr>
<tr>
<td>Low</td>
</tr>
<tr>
<td>Very low</td>
</tr>
</tbody>
</table>

6. What proportion of teachers at your school acted as good role models by eating healthy foods in the last 12 months?  

<table>
<thead>
<tr>
<th>Ticket Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>All or almost all</td>
</tr>
<tr>
<td>Most</td>
</tr>
<tr>
<td>About half</td>
</tr>
<tr>
<td>Some</td>
</tr>
<tr>
<td>Very few or none</td>
</tr>
</tbody>
</table>

7. Overall, how effective was your school at promoting healthy eating among students in the last 12 months?  

<table>
<thead>
<tr>
<th>Ticket Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very effective</td>
</tr>
<tr>
<td>Moderately effective</td>
</tr>
<tr>
<td>Not very effective</td>
</tr>
<tr>
<td>Not effective at all</td>
</tr>
</tbody>
</table>

**Physical Education, Sports and Physical Activity**

Questions 8, 9 and 10 relate to a written policy that promotes sport and other physical activity

8. Does your school have a written school sport or physical activity policy?  

<table>
<thead>
<tr>
<th>Ticket Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yes</td>
</tr>
<tr>
<td>No (If no, tick response and go to question 11)</td>
</tr>
<tr>
<td>Not sure</td>
</tr>
</tbody>
</table>
9. What proportion of teachers and parents do you think are aware of this policy? Please tick one response for teachers and one response for parents.

<table>
<thead>
<tr>
<th>Teachers</th>
<th>Parents</th>
</tr>
</thead>
<tbody>
<tr>
<td>All or almost all</td>
<td>(1) (1)</td>
</tr>
<tr>
<td>Most</td>
<td>(2) (2)</td>
</tr>
<tr>
<td>About half</td>
<td>(3) (3)</td>
</tr>
<tr>
<td>Some</td>
<td>(4) (4)</td>
</tr>
<tr>
<td>Very few or none</td>
<td>(5) (5)</td>
</tr>
</tbody>
</table>

10. How good was the school’s compliance with this policy in the last 12 months?

<table>
<thead>
<tr>
<th>Tick response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very good</td>
</tr>
<tr>
<td>Good</td>
</tr>
<tr>
<td>OK</td>
</tr>
<tr>
<td>Poor</td>
</tr>
<tr>
<td>Very poor</td>
</tr>
</tbody>
</table>

At your school in the last 12 months, how adequate was the:

<table>
<thead>
<tr>
<th>At your school in the last 12 months, how adequate was the:</th>
<th>Very adequate</th>
<th>Adequate</th>
<th>Inadequate</th>
<th>Very inadequate</th>
</tr>
</thead>
<tbody>
<tr>
<td>11 Area for outdoor play?</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>12 Area for indoor play?</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
<tr>
<td>13 Sporting and active play equipment (e.g. bats, balls)?</td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
</tr>
</tbody>
</table>

14. How accessible was the sports equipment to all students outside of PE periods and sport in the last 12 months?

<table>
<thead>
<tr>
<th>Tick response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almost unlimited access</td>
</tr>
<tr>
<td>Moderate access</td>
</tr>
<tr>
<td>Limited access</td>
</tr>
<tr>
<td>Very limited access</td>
</tr>
</tbody>
</table>
15. Rate the strength of the links that the school had with community sporting and recreation organisations and facilities in the last 12 months:

<table>
<thead>
<tr>
<th>Tick response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Very strong</td>
</tr>
<tr>
<td>Strong</td>
</tr>
<tr>
<td>Moderate</td>
</tr>
<tr>
<td>Weak</td>
</tr>
<tr>
<td>Very weak</td>
</tr>
</tbody>
</table>

16. What proportion of teachers at your school acted as good role models by being physically active in the last 12 months?

<table>
<thead>
<tr>
<th>Tick response</th>
</tr>
</thead>
<tbody>
<tr>
<td>All or almost all</td>
</tr>
<tr>
<td>Most</td>
</tr>
<tr>
<td>About half</td>
</tr>
<tr>
<td>Some</td>
</tr>
<tr>
<td>Very few or none</td>
</tr>
</tbody>
</table>

17. What proportion of parents at your school supported school-based physical activity programs in the last 12 months (i.e. by attendance at events, supervision, volunteering, etc.)?

<table>
<thead>
<tr>
<th>Tick response</th>
</tr>
</thead>
<tbody>
<tr>
<td>All or almost all</td>
</tr>
<tr>
<td>Most</td>
</tr>
<tr>
<td>About half</td>
</tr>
<tr>
<td>Some</td>
</tr>
<tr>
<td>Very few or none</td>
</tr>
</tbody>
</table>

18. To what degree had your school implemented programs or strategies to reduce traffic congestion around the school in the last 12 months?

<table>
<thead>
<tr>
<th>Tick response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Strategies/programs have been fully implemented</td>
</tr>
<tr>
<td>Strategies/programs have been partly implemented</td>
</tr>
<tr>
<td>Strategies/programs have not been implemented</td>
</tr>
<tr>
<td>Not applicable as traffic congestion was not a problem</td>
</tr>
</tbody>
</table>
### Questionnaire Responses

<table>
<thead>
<tr>
<th>Question</th>
<th>Response Options</th>
<th>Tick response</th>
</tr>
</thead>
<tbody>
<tr>
<td>How adequate was the cycle storage facilities at your school in the last 12 months?</td>
<td>Very adequate</td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>Adequate</td>
<td>(2)</td>
</tr>
<tr>
<td></td>
<td>Inadequate</td>
<td>(3)</td>
</tr>
<tr>
<td></td>
<td>Very inadequate</td>
<td>(4)</td>
</tr>
<tr>
<td></td>
<td>No students cycle to school</td>
<td>(5)</td>
</tr>
<tr>
<td>In the last 12 months, how much did nutrition and physical activity classroom assignments encourage students to make changes at home?</td>
<td>Strongly encouraged</td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>Somewhat encouraged</td>
<td>(2)</td>
</tr>
<tr>
<td></td>
<td>Slightly encouraged</td>
<td>(3)</td>
</tr>
<tr>
<td></td>
<td>Didn’t encourage</td>
<td>(4)</td>
</tr>
<tr>
<td>In the last 12 months, the school encouraged participation by ALL students in sports and other physical activities (e.g. not allow highly skilled students to dominate activities and games):</td>
<td>Strongly agree</td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>Agree</td>
<td>(2)</td>
</tr>
<tr>
<td></td>
<td>Neither agree nor disagree</td>
<td>(3)</td>
</tr>
<tr>
<td></td>
<td>Disagree</td>
<td>(4)</td>
</tr>
<tr>
<td></td>
<td>Strongly disagree</td>
<td>(5)</td>
</tr>
<tr>
<td>Overall in the last 12 months, how effective was your school at promoting physical activity among students?</td>
<td>Very effective</td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>Moderately effective</td>
<td>(2)</td>
</tr>
<tr>
<td></td>
<td>Not very effective</td>
<td>(3)</td>
</tr>
<tr>
<td></td>
<td>Not effective at all</td>
<td>(4)</td>
</tr>
</tbody>
</table>

*End of Part 1. Part 2 starts on next page*
Canteen Manager (or Food Service Operator)

School Environmental Audit & Readiness Capacity Survey

Schools can influence student’s nutrition and physical activity behaviours in many ways (policies, curriculum, role modelling, etc.). This survey is divided into two parts. Part 1 is an environmental audit to attain a picture of your schools policies and practices relating to nutrition and physical activity. Part 2 contains questions on community readiness capacity for understanding where schools are situated in relation to engaging with the problem of childhood obesity.

Instructions

The audit section has three sets of questions according to participant:

Survey 1 is to be filled out by the Principal or a Senior Administrator;

**Survey 2** (this survey) is to be filled out by the Canteen Manager or food service operator;

Survey 3 is to be completed by at least 3 Teachers from your school.

Surveys 1 and 3 are not included in this document. The readiness capacity section of each survey is identical.

The survey will take approximately 30 minutes to complete per person. All parts of the survey are self-administered.

Answer the questions honestly; your answers will remain confidential. Where research related to this information is reported, your name and your school will not be identified.

Thank you for taking the time to complete this survey.

Please place (1) the completed survey; (2) signed consent form; and (3) a copy of your canteens current price list (including all items for sale) in the enclosed envelope, and return to the school office in the box provided.
Part 1: School Environmental Audit

Thank you for taking the time to complete this audit. This should be answered by someone who has a close working knowledge of the school food service such as a canteen manager or food service operator. Please answer the questions as best as you can. The contents of this survey will remain confidential to the research team and to your school. Where research related to this information is reported, your school name will not be identified.

School name: __________________________________________  [ ] [ ] [ ] [ ]

Type of school:  

[ ] Primary school (1)  
[ ] Combined Primary-Secondary school (2)  
[ ] Secondary school (3)

Your name: __________________________________________

Your phone number: ____________________________________  
(if needed for clarification of responses)

Date of completion of survey: ___________________________

What is your position?  

[ ] Canteen manager (3)  
[ ] Other ________________________________

Initials of survey administrator: ________________________
### Food and Nutrition

<table>
<thead>
<tr>
<th></th>
<th>Question</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>In the previous 12 months, how many days per week did the school food service operate? <em>Please circle response</em></td>
<td>0 (go to question 8) 1 2 3 4 5</td>
</tr>
<tr>
<td>2</td>
<td>Which of the following times during the day was the school food service open to students?</td>
<td>Tick all that apply</td>
</tr>
<tr>
<td></td>
<td>Before school starts</td>
<td>(1,0)</td>
</tr>
<tr>
<td></td>
<td>Recess / breaks</td>
<td>(1,0)</td>
</tr>
<tr>
<td></td>
<td>Lunch time</td>
<td>(1,0)</td>
</tr>
<tr>
<td></td>
<td>After school</td>
<td>(1,0)</td>
</tr>
<tr>
<td></td>
<td>It's open the entire school day</td>
<td>(1,0)</td>
</tr>
<tr>
<td>3</td>
<td>How adequate was the space at school for food preparation in the last 12 months?</td>
<td>Tick response</td>
</tr>
<tr>
<td></td>
<td>Very adequate</td>
<td>(1)</td>
</tr>
<tr>
<td></td>
<td>Adequate</td>
<td>(2)</td>
</tr>
<tr>
<td></td>
<td>Inadequate</td>
<td>(3)</td>
</tr>
<tr>
<td></td>
<td>Very inadequate</td>
<td>(4)</td>
</tr>
<tr>
<td></td>
<td>Not applicable</td>
<td>(99)</td>
</tr>
<tr>
<td>4</td>
<td>In the last 12 months, were the following foods and beverages usually (most days of the week) available from the school food service?</td>
<td>Yes (1) No (0)</td>
</tr>
<tr>
<td></td>
<td>Fruit</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Vegetables (e.g. corn cob)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Salad options</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Milk (including flavoured milk)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yoghurt</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Filled rolls/sandwiches</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Lollies/chocolate</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hot chips</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Crisps</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pies</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sausage rolls</td>
<td></td>
</tr>
<tr>
<td></td>
<td>100% fruit juice</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Sugar drinks (soft drinks, sports drinks and fruit cordials)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Water</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ice blocks, icy poles or ice creams</td>
<td></td>
</tr>
</tbody>
</table>
In the last 12 months:

5 Did the school food service have a pricing policy that encouraged the sale of healthy food choices at a reduced cost?  
   Yes (1)  
   No (0)  
   Don’t know (99)

6 Did the school food service routinely promote and advertise healthy food choices (e.g. highlight healthy foods on menu, offer taste testing opportunities for new food, have best position in food displays)?

7 How often did the school food service review the food and drinks available in the last 12 months?  
   Tick response
   Never (0)  
   Less than once a year (1)  
   About once a year (2)  
   About once every 6 months (3)  
   About once a term (4)  
   Once a month or more (5)

How many:

8 Vending machines did your school have in the last 12 months?  
   (if none, answer 0 and go to question 11)

9 Of these vending machines sold drinks alone?  
   (if none, answer 0)

10 Vending machines were accessible for staff alone?  
   (if none, answer 0)

11 How many water fountains or drinking taps were in your school in the last 12 months?  
   Please circle response
   0 (0)  
   1-3 (1)  
   3-6 (2)  
   7-10 (3)  
   More than 10 (4)

12 Please attach a copy of your canteens current price list including all items for sale

End of Part 1. Part 2 starts on next page
School Council/Committee Representative
School Readiness Capacity Survey

Instructions

This survey should be answered by a school council/committee representative who has knowledge of school practice in relation to childhood obesity prevention. This survey uses a community readiness framework for assessing where school communities are at in relation to engaging with the problem of childhood obesity. Community readiness is defined by 6 dimensions: knowledge about obesity; school efforts, and knowledge of school efforts to prevent obesity; leadership support; school climate; and availability of resources for prevention efforts. Responses to questions are scored and aggregated across the school to give an overall score of readiness.

The survey will take approximately 20 minutes to complete. All parts of the survey are self-administered.

Please answer each question as best as you can. The contents of this survey will remain confidential to the research team and to your school. Where research related to this information is reported, your school name will not be identified.

Thank you for taking the time to complete this survey.

Please return the completed survey and signed consent form in the enclosed envelope to the school office in the box provided.
To be completed by a school council/committee representative

School name: ______________________________________

Type of school:  
- Primary school
- Combined Primary-Secondary school
- Secondary school

Your name: ______________________________________

Your phone number: ______________________________________  
(if needed for clarification of responses)

Date of completion of survey: _________________________________

What is your position?  
- School Council/committee chairperson
- School council/committee member
- Other _________________________________

Initials of survey administrator: _________________________________
School Readiness to Address Childhood Obesity

1. Using a scale from 1-10, how much of a concern is childhood obesity to your school (with 1 being “not a concern at all” and 10 being “a very great concern”)?

   *Please circle response*

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
</table>

Please explain:

---

Dimension A: School Efforts (programs & activities)

2. Are there programs or activities in your school that address childhood obesity?

   *Please circle response*

<table>
<thead>
<tr>
<th>Yes</th>
<th>Continue to question 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>No</td>
<td>Skip to question 8</td>
</tr>
</tbody>
</table>

3. Can you please describe these?
<table>
<thead>
<tr>
<th></th>
<th>Question</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>How long have these efforts been going on in your school?</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Is there any evaluation of the current efforts?</td>
</tr>
<tr>
<td></td>
<td><em>Please circle response</em></td>
</tr>
<tr>
<td></td>
<td>Yes</td>
</tr>
<tr>
<td></td>
<td>No</td>
</tr>
<tr>
<td>5a</td>
<td>On a scale of 1 to 10, how sophisticated is the evaluation effort (with 1 being “not at all” and 10 being “very sophisticated”)? <em>Please circle response</em></td>
</tr>
<tr>
<td></td>
<td>1  2  3  4  5  6  7  8  9  10</td>
</tr>
<tr>
<td>5b</td>
<td>Are the evaluation results being used to make changes in efforts or to start new ones?</td>
</tr>
</tbody>
</table>
**Dimension B: School Community Knowledge of Efforts**

*School community: inclusive of (but not limited to): teachers, staff, students and parents*

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Not including those directly involved in planning or implementing efforts addressing childhood obesity, approximately how many in your school community are aware of these efforts? Would you say none, a few, some, or most? Please explain.</td>
</tr>
<tr>
<td>7</td>
<td>What do these individuals know about these efforts or activities? e.g. Can they identify specific efforts, do they know their purpose of the efforts, who they target, what they do, the effectiveness of the efforts?</td>
</tr>
<tr>
<td>8</td>
<td>Is anyone in your school community trying to get something started to address childhood obesity? For example has anyone started discussing possibilities or planning any efforts? Please explain.</td>
</tr>
</tbody>
</table>
### Dimension C: Leadership

**9** Using a scale from 1-10, how much of a concern is childhood obesity to the leadership of your school (with 1 being “not a concern at all” and 10 being “a very great concern”)? *Please circle response*

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
<th>10</th>
</tr>
</thead>
</table>

Please explain:

---

**10** Does leadership believe that childhood obesity is an issue that should be addressed in your school? Please explain.

---

**11** How is the leadership involved in efforts regarding childhood obesity? For example, are leaders simply supportive or are they more actively involved (e.g. are they involved in a committee, do they speak out publicly, have they allocated resources to address childhood obesity?) Please explain.
12. Would school leadership support additional efforts? If so, how might they do that?

Dimension D: School Climate

13. Do school community members (e.g. students, teachers, staff, parents, council/committee members) believe that childhood obesity is an issue that should be addressed in the school? *Please circle response*

| Yes | Continue to question 13a |
| No  | Skip to question 13b |

13a. If yes, how might they show this support, e.g. passively or actively by being involved? Please explain.

13b. What do you think is the overall attitude among members of your school community regarding childhood obesity? e.g. supportive, concerned, indifferent, resistant?
Dimension E: Knowledge about Childhood Obesity

14 On a scale of 1 to 10, how much knowledge do school members have about childhood obesity in terms of risk factors, causes, consequences, etc. (with 1 being “no knowledge” and 10 being “a detailed knowledge”)?

Please circle response

1 2 3 4 5 6 7 8 9 10

Please explain:

---

15 How much do school members know about childhood obesity as it pertains to your school? (e.g. prevalence, effect on students/family/friends?)

---
Dimension F: Resources for Prevention Efforts (time, money, people, space, etc.)

If there are no current efforts to address childhood obesity, skip to question 18.

16. How are current efforts funded?

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>16</td>
<td></td>
</tr>
</tbody>
</table>

17. What other resources are currently being used to address childhood obesity in your school (e.g. space, volunteers, nutrition/physical activity experts)?

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>17</td>
<td></td>
</tr>
</tbody>
</table>

18. What other resources are available to address childhood obesity in your school (e.g. space, volunteers, nutrition/physical activity experts, financial donations from organisations)? Is anyone in the school looking into using these resources to address childhood obesity?

<table>
<thead>
<tr>
<th>Question</th>
<th>Answer</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td></td>
</tr>
</tbody>
</table>
19. Would your school support using these resources to address childhood obesity? Please explain.

20. Are you aware of any proposals or action plans that have been submitted for funding that address childhood obesity prevention in your school? If yes, please explain.

End of survey

Thank you for your participation
# Friends & Health Study: Anthropometric Data

**School Name:**

**Measurer:**

**Date:**

**Time:**

**School ID:**

**Equipment set no.:**

---

## Anthropometric Data

<table>
<thead>
<tr>
<th>Student ID</th>
<th>Student Name</th>
<th>Date of Birth</th>
<th>1st measure</th>
<th>2nd measure</th>
<th>3rd measure</th>
<th>1st measure</th>
<th>2nd measure</th>
<th>3rd measure</th>
<th>1st measure</th>
<th>2nd measure</th>
<th>3rd measure</th>
<th>Accelerometer No.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

*All measures to the nearest 0.1 cm. Take 3rd measure if difference:*

- Height (cm): >= 0.5cm
- Weight (kg): >= 0.5kg
- Waist circumference (cm): >= 0.5cm

---

**Comments**

---

Page 1 of 1
Friends & Health Behaviour over the Primary to Secondary School Transition

Social Network Data Entry

Background

The design of this research is a longitudinal cohort study, following students from their last year (grade 6) primary school to their first year (year 7) secondary school. Some year 5 students were also recruited and followed to year 6. The aim of the study is to see how the change from primary to secondary school impacts upon their physical activity and eating behaviours. Part of this research is to look at the influence of friends on individual behaviour.

313 students consented in 2013. 310 of these participated in 2013. 311 participated in 2014 (2 were lost to follow-up; 3 participated at one time only). Friends of students from schools in one region were also recruited into the study in 2014. There were a total of 339 participants in 2014: 81 primary school and 258 secondary school students.

All students were asked to complete a behavioural survey. The survey had a 2 page section at the end which asked the participants who their friends are that they ‘hang around with the most’ at recess, lunch, after school and on weekends. Other questions are: who of their friends they usually eat meals/snacks with, play sport with; how healthy they think the food their friends eat, and how active they think their friends are.

The format of this section of the survey is like a spreadsheet, where the student can write their friends names (1 name per row), and tick the applicable answer in the corresponding column/s. There is space for up to 15 names. See sample survey.

Data entry into Excel

Data from each student survey is to be entered into an Excel spreadsheet in a similar format to how it is entered by the student on the survey. All students within one school are to be entered on the same school spreadsheet, with a separate spreadsheet per school.

42 schools participated in 2014, with the number of students ranging from 1 to 38 per school.

In 2014 there are:

- 6 combined primary-secondary schools (e.g. Prep to year 12), where most students have stayed at the same school from 2013 to 2014
- 3 primary schools with year 6 students (these schools participated in 2013 when students were in year 5)
- 2 primary schools that did not participate in 2013 (students were in different primary schools in 2013; 1 student at each school)
- 31 secondary schools (participated in 2014 only)
Types of data

There are 3 different types of data for entry:

1. Attribute data (i.e. student ID, surname, first name, gender, grade/year, at this school or not, participant or not) for each student either participating or friend nominated in the study.
2. Summary data for each participant. This is a list of all participants at each school with totals by row for the number of friends per each question by column. This can done by counting the number of responses on each student’s questionnaire and entering by row on the summary spreadsheet per school. Row totals can be added as a cross check to ensure all data has been accounted for.
3. All data per participant. This is the detail of each student’s response, listing all the friends of a student by name, with all the responses by row/column. The critical thing to watch is that the student ID is correctly recorded against the student’s name.

Cluster schools

Most schools in the study are only related to one another by the students that attend the local primary and then secondary school. The exception is a cluster of schools within one geographic region, where students may have friends in other schools in the region. This is an issue when it comes to giving individual ID’s to students – we need to check if the friend has already been given an ID at another school to make sure there is only one ID per student.

It is also this cluster of schools were students could ask their friends if they also wanted to join in the study. 28 friends of students completed a survey in 2014 (but not in 2013).

To check there are no duplicates of IDs for students within the cluster of schools, it is best to first compile a list of all the students from all the cluster schools using 2013 data. Then as names of friends are added, they can be assigned IDs. This complete list can be copied to each new spreadsheet per school on a separate tab, and used as a lookup table when entering the data on a separate tab per school.

Procedures

Preliminary

• Have list of participant student ID’s for reference
• There is one manila folder per school, with all student surveys in the folder. Take one folder at a time.
• Start a new spreadsheet for each school. Take the names from the corresponding 2013 spreadsheet to use for the 2014 spreadsheet
• If using 2013 template, make sure all non-formula numeric is zeroed out from the ‘summary’ and ‘all’ (except the alter participant column) data tabs.

NB. The following procedures may differ slightly for the regional school cluster, due to the potential for participants to have common friends at other schools, and students changing schools. A list of all students for the regional cluster of schools should be used as a reference.
Attribute data

1. Student attribute data is to be recorded on the first tab of a school spreadsheet
2. Use the list of student ID's from 2013 as a starting point.
3. The year level needs to increase by 1 in 2014. Rename the year level column to ‘2013 year level’. Insert another column before the 2013 year level column and enter the title ‘2014 year level’. Use a formula to populate this column to add 1 year to all year levels (e.g. +D3+1). Move the 2013 year level column to the last column
4. Look at one survey at a time in a school folder. Write the student ID on top right hand corner of survey of question 37 for reference (use the ID number recorded on the cover page of the survey)
5. Using list of existing ID's in the attribute tab, record ID numbers against each friend listed on the survey (use a different colour pen and write next to the friend’s first or surname on the survey). It is easier if the existing list is sorted first by surname (make sure all data is included when sorting).
6. If the name of a friend on the survey is not listed in the spreadsheet, first check if the friend is on a list at another school (2013 primary school listing), and use their ID if there is one. If not, add the name at the end of the list with relevant details (grade/year level, gender, at this school, participant). Sometimes the name is spelt differently on the survey – make sure there are no names duplicated. All new names added will be non-participants (i.e. friends of participants). All participants already have an existing ID.
7. Record the new ID against the relevant name on the hardcopy survey
8. Repeat 3-7 for all the surveys in one school
9. When all the names of friends have been listed on the spreadsheet, sort the list (make sure all data is included when sorting) by ID then surname.
10. Generate the next consecutive ID number. E.g. ABX09 where AB is the school code, X (or Y) is the code for non-participants, and 09 is the next consecutive number to assign
11. For the regional cluster school students only, add new nominated friends to regional cluster list
12. Make sure the final list is sorted by ID ready for data entry

Summary data

1. Use the summary tab on the same school spreadsheet (copy format from another school if for a new school). This is a summary of all participant data.
2. Check that all participants within the school are listed (with ID, surname, first name), one name per row
3. One survey is used to populate 1 row on the summary spreadsheet.
4. Next check the coding of question 38. Some questionnaires are an old design and have the scoring reversed. The coding should be:

   Type of food and drink: 3: Mostly healthy; 2: Part healthy, part unhealthy; 1: Mostly unhealthy
   How active: 3: Very active; 2: Sometimes active; 1: Not very active

5. Enter summary details per participant per row. Under the ‘total out-degree’ column, type the total number of friends listed on the survey. Then put the relevant total number of friends per question/column (e.g. total number of friends that are male, total number of friends they hang around with at lunch, total number of friends that are very active, etc.)
6. Check the formulas and results at the end of the table to make sure all data has been entered

All data

1. Use the ‘All’ tab to enter detailed data per student. Previous years data may already exist on this tab – make sure the numeric data is zeroed out first. If it is easier not to have the names already listed, then they can be deleted and the spreadsheet started from scratch. If not, the existing names can be used (just need to double check each time that the friend’s name is on the same row as the participant’s name)
2. First check the lookup formula is capturing the correct range of data (all IDs and names) from the Attributes tab. Update the formula and copy to relevant cells as needed
3. Enter 1 survey at a time. On the spreadsheet there will be one row for each friend listed, with the participant’s name also on each row
4. If leaving existing names on the spreadsheet, find the correct row to enter the data according to the participant ID (ego) and friend ID (written on the survey)
5. Enter the 8 items of data (from recess to how active). The alter participant column will already be populated if using existing names, else this can be populated later
6. If not using existing names, or if the friend is not listed, create a new row for the relevant participant. Enter the ID for the participant (ego) and friend (alter) and check the names are correctly populated from the lookup table. If not, check all the formulas are correct and the ID has been entered correctly.
7. Enter the relevant details per row by friends name
8. If a name is listed on the spreadsheet against a participant but not needed, delete the row
9. Repeat 3-6 for each survey for that school.
10. Check that the ‘ego name check’ and ‘alter name check’ columns are all showing TRUE. If not, check the spelling and/or ID of participant/friend for entries showing FALSE
11. Check/update the formulas on the summary tab to include all rows from the ‘All’ tab. Check any differences if the ‘check’ on the summary tab are not zero. Check all totals.

Final check

When all participants’ data have been entered for all schools, conduct a final data entry check for 10% of participants.
Appendix D  Draft final report for schools
Friends and health behaviour over the primary to secondary school transition

Report for schools

Introduction
This short report was prepared by Jennifer Marks, a PhD student at Deakin University who conducted the study entitled ‘Friends and health behaviour over the primary to secondary school transition’.

This study looked at how changing from primary to secondary school might change health behaviours of physical activity (PA), sedentary/screen time, and food/drink intake. The study was conducted with staff and students in Victorian primary and secondary schools in 2013 and 2014.

This report gives an overview of what the study was about, and what we found.

Background
Within Australia, 22% of primary school children and 29% of secondary school children/adolescents are overweight. Children and adolescents who are overweight can suffer from poor self-esteem and being excluded by their peers. They are also at risk of a number of serious long term health problems, such as diabetes and heart disease.

Healthy eating and being physically active can lower the risk of becoming overweight and developing health problems. Yet many children and adolescents are not getting enough physical activity, spend too much sitting/screen time, and eat too much food/drink that are high in sugar and low in nutrients.

Schools (and the family home) have a very strong influence in childhood and adolescence. And when students progress from primary to secondary school they are exposed to many changes, such as school location, curriculum, teachers, friends, managing timetables, transport, and much more, all of
which can impact upon academic achievement and behaviours in some way or another. Yet we don’t know much about how changing schools can effect healthy weight behaviour. Particularly when a change of school often means a change of friends, at a time in adolescence when friends become more and more important influences on behaviour.

Who took part in the study?
Staff and students from 11 primary, 6 combined primary-secondary, and 31 secondary schools took part in the study. The first phase was conducted in term 4, 2013 with 245 year 6 students. Phase 2 was conducted with the same 243 students the following year when students were in term 2 of secondary school. Two students were not available to participate at phase 2.

What did it involve?
School principals, teachers, canteen managers and committee representatives completed a school environment and capacity survey. The school environment survey included questions on school physical activity (e.g. availability of sporting equipment within school break times) and food (e.g. healthy eating policies) environments. The capacity survey included questions on the problem of childhood obesity within the school community. The staff survey was completed once only.

At study phases 1 & 2, students completed a behaviour and friendship survey, had measurements taken (height, weight and waist), and wore an accelerometer for a measure of physical activity. The behaviour survey asked questions on physical activity, diet and screen-time. The friendship survey asked students to list the friends who they spent time with the most, and included questions such as when they spent time with their friend (e.g. recess, after-school) and their perception of how active each friend is (e.g. very active, not very active).

What was analysed?
Data from the school environment survey was used to compare physical activity and food environments between primary and secondary schools. Staff response rates were relatively low at some schools, which meant that associations between changes in student behaviour and differences between school environments could not be made. Also due to staff response rates, results of the
school community surveys on obesity could not be made for all schools. Reports for individual schools, where available, will be provided upon request.

To understand how changing schools might change behaviour we had two groups of children in the study, one group went from primary to a separate secondary school. The second group of students attended the same combined primary-secondary type school from year 6 to year 7.

Student data were analysed to address the following questions:

- What behaviours changed between primary and secondary school (for all students)?
- Was there a difference in behaviour between students who did, and students who did not change school over the year 6 to year 7 period?

Also we looked at children’s friendships groups to try and understand how friends might influence their behaviour.

What did we find?

Weight status
There was very little change in students’ weight between primary and secondary school. At primary school, 64% (69% female; 58% male) students were of normal weight and 36% (31% female; 42% male) were overweight or obese. At secondary school, 62% (67% female; 55% male) students were of normal weight, and 38% (33% female; 45% male) were overweight or obese. We did not expect students’ weight to change much over such a short period of time.

Physical activity
We found that the average amount of time being very active each day (defined as moderate-to-vigorous physical activity, MVPA), dropped when students attended secondary school. We also found that when students were in secondary school, the amount of time being very active (MVPA) increased after school (Figure 1).

During the school day, students were more active during PE at secondary school, but less active at recess and lunch times. Students also felt less encouraged to be active at lunch time at secondary school compared to primary school.
The biggest change in physical activity was at recess and lunch times. There was an even bigger change for students who went to a different school when they went to secondary school (compared to students who stayed at the same primary-secondary type school). For students who changed school, Figure 2 shows that most students were active at lunch time in primary school, but not at secondary school lunch breaks.

![Physical activity student ratings at primary and secondary school](image)

**Figure 1 Physical activity student ratings at primary and secondary school**

The biggest change in physical activity was at recess and lunch times. There was an even bigger change for students who went to a different school when they went to secondary school (compared to students who stayed at the same primary-secondary type school). For students who changed school, Figure 2 shows that most students were active at lunch time in primary school, but not at secondary school lunch breaks.

![School lunch break physical activity intensity levels for the same students when attending (a) primary school and (b) a different school at secondary school](image)

**Figure 2 School lunch break physical activity intensity levels for the same students when attending (a) primary school and (b) a different school at secondary school. These results showing a drop in physical activity intensity are for students who changed school only between primary and secondary school.**
Sedentary/screen time

On average, secondary school students were more sedentary than when they were at primary school. We also found that less students watched television, and more students used computers for fun and homework when they were at secondary school compared to when they were at primary school (Figure 3).

![Figure 3 Leisure screen time > 2 hrs/day & Usual screen type behaviour](graph)

There was a big difference in the amount of recreational computer time between students who changed schools, and students who stayed in the same primary-secondary type school. On average, students who changed schools had an *increase* in screen time, whereas students who remained in the same primary-secondary school *reduced* the amount of time they spent using computers for recreation (Figure 4).

![Figure 4 Difference in leisure screen time from primary to secondary school between students who changed schools, and students who did not change schools](graph)
Student diet

Transitioning to secondary school had both a positive and negative effect on student diets. On average, intake of non-core foods (e.g. chips, biscuits) and sweet drinks, decreased. But fruit and vegetable intake also decreased after the move to secondary school. On a positive note, students felt they were more encouraged to make healthy food choices, and had teachers as healthy role models at secondary school.

There were also differences between students who did, and did not change schools. Overall, intake of sweet drinks, frequency of fruit/vegetable classroom breaks, frequency of purchasing snack foods, and encouragement to eat healthily were more favourable with students who did not change schools between primary and secondary school (Figure 5).

Figure 5 Change of ratings of dietary intake and perceptions with comparison between students who changed schools, and students who did not change schools, from primary to secondary school. Negative values show a decrease in scale (e.g. -1 result for fruit/vegetable classroom break means 1 less weekday)
School environment: primary to secondary

On average, there were notable differences in school physical activity and food environments between primary and secondary schools as reported by school staff. Areas of significant difference are shown in Table 1. For example, on average primary schools allocated more time for recess than secondary schools. More secondary schools reported having a written electronic device policy than primary schools. Whilst these results may be indicative of the sampled schools, response rates were generally lower from secondary schools, and as such, results should be interpreted with caution.

Table 1: School PA and food environments

<table>
<thead>
<tr>
<th>Areas of significant difference between primary and secondary schools</th>
<th>Primary</th>
<th>Secondary</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time allocated for recess</td>
<td>✔️</td>
<td></td>
</tr>
<tr>
<td>Existence of written personal electronic device policy</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Adequacy of sport/play equipment</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Equipment accessibility outside of PE/sport</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>School encourages all student sport participation</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Existence of written school nutrition or healthy canteen policy</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Nutrition/healthy canteen policy compliance</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Proportion of teachers as good healthy eating role models</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>Number of days per week school food service operated</td>
<td>✔️</td>
<td>✔️</td>
</tr>
<tr>
<td>School food service open to students before school</td>
<td>✔️</td>
<td>✔️</td>
</tr>
</tbody>
</table>

School environment: capacity to address childhood obesity

There was a wide range of responses by schools of awareness and capacity of the school community to address childhood obesity. Overall, most feel there is a local concern, but there is no immediate motivation to address this at a school level. As mentioned, some staff responses were low, therefore data is not available for all schools. Please advise if you would like more information pertaining to your school and region.
Friends
We found different characteristics of student's friendship groups (networks) were related to either an increase, or decrease, in behaviour. And these were mostly different for males and females (Table 2). In general, boys’ friendship networks mostly had an effect on their physical activity. But for girls, their friends had more of an effect on screen time and intake of sweet drinks.

Table 2: Network friendship characteristics associated with increases or decreases in physical activity, sedentary/screen time and/or dietary intake

<table>
<thead>
<tr>
<th>Network characteristic</th>
<th>Physical activity¹</th>
<th>Sedentary time²</th>
<th>Dietary intake³</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Males</td>
<td>Females</td>
<td>Males</td>
</tr>
<tr>
<td>Number of friends</td>
<td>+</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Very active friends</td>
<td>+</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Friends to play sport with</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Longer term friends</td>
<td>+</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Same sex friends</td>
<td>+</td>
<td></td>
<td>+</td>
</tr>
<tr>
<td>Very 'healthy' friends</td>
<td></td>
<td></td>
<td>-</td>
</tr>
</tbody>
</table>

+ = positive association (e.g. more friends = more PA)
- = negative association (e.g. more friends = less PA)
1. Physical activity intensity and/or time within and outside of school
2. Average sedentary time (males); Weekend screen time (females)
3. Non-core food intake (males); sweetened beverages (females)

What does it mean?
A change of school between primary and secondary school has an impact on obesity risk behaviour within and outside of school. Different types of influences at primary and secondary schools may impact behaviour, positively or negatively. A change of physical and social environment over the school transition has more of an effect on physical activity and screen time than dietary intake. This may be due to the home environment having more of a stronger influence on diet.

And friends really make a difference. We found that students (male and female) who played sport with friends at primary school were more likely to be physically active in secondary school. Having more friends is also important for boys to keep being active. But for girls, having more friends can mean spending more time with friends on electronic media (e.g. Facebook, etc.).
Recommendations
The key findings from this study, i.e. that changing schools can have a negative effect on health related behaviour, demonstrates the importance for schools to have consistency of policy and supportive environments for promoting and reinforcing healthy weight behaviour throughout the primary and secondary years of schooling. Consistent with the WHO health promoting school framework to strengthen school capacity by incorporating healthy school policy, physical and social environments for improving the health of the school community (Department of Human Services 2000; World Health Organization 2015), supportive environments for healthy weight behaviour needs to be maintained and reinforced as students transition between school types. For example, consistency of healthy canteen/food and personal electronic device policies, and providing supportive environments to promote and encourage physical activity (e.g. provision of sporting equipment within school breaks) at primary, middle and secondary schools. It is also important that we consider how to include peer groups to help promote and establish healthy behaviours in adolescence.

Acknowledgements
Thank-you to all the staff and students at participating schools – you were wonderful to work with. I would like to acknowledge the support of my PhD supervisors Professor Steven Allender, Dr Lisa Barnett and Dr Kayla de la Haye, and Deakin University. This study was supported by a grant from the Windermere Foundation. We also acknowledge the support of the Department of Education and Early Childhood Development, Victorian Catholic Education Diocese, participating schools and students, and data collectors who made this research possible.

If you would like to look at more detail from this study, please refer to the listed publications.
References/publications


If you have any questions or comments please contact:

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Burwood Campus
Email: jennifer.marks@deakin.edu.au
Phone: 03 9244 6258
Appendix E  Honours papers publications

E1 ‘Whole of system’ intervention points for obesity prevention: a case study from a long day care setting

E2 Using Social Network Analysis to Identify Key Child Care Centre Staff for Obesity Prevention Interventions: A Pilot Study
'Whole of system' intervention points for obesity prevention: a case study from a long day care setting

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The consensus that obesity is a complex problem has led to calls for ‘whole of system’ approaches to intervention that address multiple levels of influence, from individual behaviours through to policy change.1 In this letter, we provide a case study applying a systems perspective to identify influences on childhood obesity and determine potential system-level points for intervention2 within the long day care setting.

Two long day care centres from previously successful obesity prevention interventions were recruited to allow discussion with childcare practitioners receptive to obesity prevention opportunities. Interviews were conducted separately with the regional childcare co-ordinator and a centre director, and a joint interview was held with a centre director and cook. Interview guides were based on a systems framework covering: organisation (reporting structure), network (working relationships) and knowledge (e.g. policy/guidelines) elements3 with reference to centre influences on children’s eating and activity behaviours. Qualitative interview data were used to compile system maps.

Influences on children’s dietary and activity behaviours were identified within multiple system elements (Figure 1). Participants described how existing systems promote healthy dietary and activity behaviours, including “a very strong commitment at a local government level to health and well-being” (regional childcare co-ordinator), a supportive management structure, collaborative policy development and continued implementation of integrated physical activity and nutrition programs. These programs were instrumental in interpreting and applying national childcare guidelines and giving rise to a nutrition program childcare centre ‘champion’, providing evidence that centre ‘systems’ were amenable to change. Promoting health and well-being within the early childhood community was also a priority of the centres, providing some insight to the extent of network influence.

An emphasis on what works for finding solutions to complex system problems has been proposed as a basis for identifying a hierarchy of places to intervene in a system.2 Results from this study can be aligned against each level of the hierarchy suggesting potential for multi-component policies and programs supporting change ‘across the system’. This case study demonstrates capacity for applying a systems framework from a practitioner’s perspective, breaking down the complexity of a long day care system, and identifies possible leverage points for effective change for the prevention of obesity in children.

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References


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Figure 1: Long Day Care (LDC) system influences on children’s dietary and activity behaviours.

Diagram depicts links between policy, programs and LDC practice to identify potential areas of leverage for obesity prevention intervention at various system hierarchies: paradigm/goals, structural connections, feedback processes, and structural elements.2
Research Article

Using Social Network Analysis to Identify Key Child Care Center Staff for Obesity Prevention Interventions: A Pilot Study

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Introduction. Interest has grown in how systems thinking could be used in obesity prevention. Relationships between key actors, represented by social networks, are an important focus for considering intervention in systems. Method. Two long day care centers were selected in which previous obesity prevention programs had been implemented. Measures showed ways in which physical activity and dietary policy are conversations and actions transacted through social networks (interrelationships) within centers, via an eight item closed-ended social network questionnaire. Questionnaire data were collected from (17/20; response rate 85%) long day care center staff. Social network density and centrality statistics were calculated, using UCINET social network software, to examine the role of networks in obesity prevention. Results. “Degree” (influence) and “betweeness” (gatekeeper) centrality measures of staff inter-relationships about physical activity, dietary, and policy information identified key players in each center. Network density was similar and high on some relationship networks in both centers but markedly different in others, suggesting that the network tool identified unique center social dynamics. These differences could potentially be the focus of future team capacity building. Conclusion. Social network analysis is a feasible and useful method to identify existing obesity prevention networks and key personnel in long day care centers.

1. Introduction

Obesity prevention efforts in childhood are needed to arrest the increasing prevalence of obesity [1–3] and its associated health risks [4]. Children's food preferences and eating patterns developed by early exposure to foods [5], along with physical activity and inactivity behaviors, have been shown to track from childhood into adulthood [6]. Regulated center-based childcare (such as long day care) may provide an opportune setting for promoting obesity preventing behaviors in preschool children [7, 8]. A systematic review in 2010 of interventions in childcare settings described one third of the studies as promising in improving children's dietary and/or physical activity behaviors [9], whereas a systematic review in 2011 of interventions in early childhood was critical of current intervention design concluding that social and environmental factors were not given adequate consideration within intervention design and implementation [10]. Those who critique intervention design argue that interventions to tackle childhood obesity must consider a complex system of individual, social, and environmental factors that impact upon eating and activity behaviors [11]. Such a dynamic interrelated system of people, processes, activities, settings, and structures [12, 13] requires a multilevel approach for prevention to be effective [14]. The World Health Organization recognizes the crucial role that people play at each level of a system: as stakeholders, beneficiaries, and mediators, as well as drivers of systems [15]. The integral nature of social interactions is also embedded within the UK National Institute of Health and Clinical Excellence (NICE) core traits of an effective whole system approach to obesity prevention [16]. This NICE review and subsequent guidance proposed a
framework for intervention that included capacity building, innovation, working relationships, community engagement, communication, policy action, and leadership [16]. It appears that social structures and relationships within a system could represent a key ingredient for intervention effectiveness, supporting the emerging literature about the importance of identifying and working in partnership with “champions” as strong internal influences and advocates for organizational change [17].

One approach to the identification of social structures and relationships within a system is the use of social network analysis (SNA). SNA describes patterns of social relations and provides a visual tool to help analyze data [18]. SNA has a history of applications within social and behavioral sciences including political systems, community networks, social supports, and group problem solving [19] and can be a useful tool to identify strengths or problems in social structures. SNA is relatively new to health settings although it has been used to: identify key people to improve knowledge sharing efficiency between specialists within hospitals [20]; understand internal/external influences for designing health-care teams [21]; identify an intervention champion within schools [22]; and identify structural needs for facilitating knowledge transfer between afterschool program teams [23].

The aim of the current study was to determine the feasibility and relevance of SNA for child obesity prevention amongst staff within a long day care setting. To address this aim, this paper asks in relation to dietary and physical activity planning within long day care (LDC) centers:

(a) What are the relational structures among child care workers that may play a role in obesity prevention practice?

(b) Can particular players be identified as key to a potential intervention?

2. Methods

2.1. Sample. We conducted surveys in July 2011 with staff of LDC centers (for children aged 0–5). Informed written consent was obtained from all participants. Ethics approval for this study was granted by the Department of Education and Early Childhood Development (2011_001186) and the relevant University Human Ethics Advisory Group (HEAG-H 63_2011).

The sample was constructed purposefully to be information rich, that is, to provide deep learning and insight [24]. We set out to engage with practitioners who were already aware of and highly sensitized to the opportunities to address obesity in long day care through their involvement in government administered obesity prevention programs. These included Romp & Chomp, which aimed to increase healthy eating and active play in early childhood settings through increasing capacity and local leadership [25], Kids Go For Your Life, which included an active play program for promoting age-related physical activity, and Start Right Eat Right, a training and healthy menu planning program for center directors and cooks. This sampling approach resulted in the inclusion of two centers within one local government area.

Each of the selected centers offered places to 35 children. Each LDC center provided lunch, morning, and afternoon snacks for children and comprised ten staff, including a center director and cook. The directors of the two centers were subsequently contacted for recruitment.

2.2. Social Network Questionnaires. A social network questionnaire was developed to articulate and allow quantification of relationships between childcare staff that could potentially influence LDC obesity prevention practice. Eight closed-ended network questions were constructed to identify: (1) frequency and (2) value (importance) of general information exchange between centers relevant to dietary and activity planning; (3) physical activity information provision and (4) consultation; (5) dietary information provision; (6) decision making and (7) consultation; and (8) network sources of policy information. Questions sought specifically to identify who provides dietary, physical activity, and center policy information, who is involved in dietary decision making with whom, and who consults with whom on information for dietary and physical activity planning to gain an understanding of existing networks. For each question, a list of staff (identified by formal job title within each center) was provided alongside a check box. For most questions, respondents were asked to indicate whether each person was relevant per question, by placing a check if there was a relationship, else leaving blank. For example, questions included: “For each position below, please indicate the type of information (dietary, policy) a person in this position provides for you to do your work,” and “please indicate who you consult with regarding the amount and type of (food/physical activity) the children are served/engage in.” Space was also provided for staff to list any key external networks relevant to information sought. For questions on the frequency and value of information, a valued response was required. Information frequency response options ranged from “never” (0), “infrequently” (1), “sometimes” (2), “frequently” (3), to “always” (4). Information value response options were: “not valuable/applicable” (0), “occasionally valuable” (1), “valuable” (2), and “very valuable” (3). All ten staff at each center were invited to complete a social network questionnaire for networks within their center. The questionnaire was piloted with a center director and administrative assistant of a LDC not in the current study. Questionnaires were subsequently modified prior to the study, primarily to reduce questionnaire length.

Written questionnaires were completed by consenting staff at each center, taking approximately ten to twenty minutes, with the researcher based in the staff room during breaks to provide assistance if required. Completed questionnaires were collected by the researcher by the end of each day or returned by mail in prepaid self-addressed envelopes. Questionnaires were analyzed using social network software (UCINET version 6.352) [26].

2.3. Social Network Analysis. Density and centralization measures were calculated for each of the eight relationships. Density is the number of ties among staff expressed as a percentage of all possible ties [19]. If all staff had direct ties...
Table 1: Density and centralization scores for each relationship.

<table>
<thead>
<tr>
<th>Relationship</th>
<th>Density (%)</th>
<th>Degree centralization (%)</th>
<th>Betweenness centralization (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LDC1</td>
<td>LDC2</td>
<td>Out In</td>
</tr>
<tr>
<td>Frequency of information</td>
<td>86</td>
<td>93</td>
<td>16</td>
</tr>
<tr>
<td>Value of information</td>
<td>85</td>
<td>98</td>
<td>17</td>
</tr>
<tr>
<td>Physical activity planning</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provision of information</td>
<td>25</td>
<td>61</td>
<td>56</td>
</tr>
<tr>
<td>Consultation</td>
<td>55</td>
<td>73</td>
<td>50</td>
</tr>
<tr>
<td>Dietary (amount and type of food)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provision of information</td>
<td>29</td>
<td>57</td>
<td>80</td>
</tr>
<tr>
<td>Decision making</td>
<td>88</td>
<td>86</td>
<td>14</td>
</tr>
<tr>
<td>Consultation</td>
<td>74</td>
<td>82</td>
<td>30</td>
</tr>
<tr>
<td>Policy (internal network)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Provision of information</td>
<td>31</td>
<td>68</td>
<td>78</td>
</tr>
</tbody>
</table>

2.4. Presentation of Results. We present results for the frequency and value of information exchanged at each center followed by results for physical activity, dietary, and policy information networks. Social network diagrams are presented for selected results to provide a visual representation to aid description and analysis. Diagrams are described in terms of nodes (network participants) connected or otherwise by lines (ties/relations) that are one directional or two directional (reciprocated) [18]. Nodes (A–J) represent staff (by job title) connected by lines (length not significant) indicating a relationship. For each center, A represents the center director, B–F room-based staff, G–I relieving staff, and J center cook.

Centers were physically structured according to children's age groupings (0–2, 2-3, and 3–5), with staff either permanently based in a room with responsibility of one age group (e.g., age 2-3 carer) or rostered to relieve a room based carer (i.e., part-time relieving staff).

3. Results

Questionnaires were completed by 17 of 20 staff (85%): 9 of 10 (90%) staff from LDC center one (LDC1) and 8 of 10 (80%) staff in LDC center two (LDC2). Respondents comprised center directors, cooks, and general staff. Density, degree centralization, and betweenness centralization results for each center and relationship are provided in Table 1.

3.1. General Information Exchange Frequency and Value. When asked about the frequency and value of information flow within the LDC setting, the high density scores for both frequency and value relationships for LDC1 (frequency score 86%; value score 85%) and LDC2 (93%; 98%) suggest that staff at both centers felt that “valuable” or “very valuable” information is provided on a very frequent basis relevant to their position at the center (Table 1).

While both out and in degree centralizations were higher in LDC1 (frequency of information exchange 16%; value of information exchange 17%) than LDC2 (frequency 8%; value 2%), betweenness centralization is low in both centers. The high density and low centrality measures for these relationships suggest that most staff share frequent and valuable information with one another through single relationships rather than through one centralized person or position (Figure 1).

3.2. Physical Activity Information Exchange. Individual staff were asked to indicate other individuals who provided them with information to plan physical activity programs. LDC2 had a density score (61%) more than twice that of LDC1 (25%) indicating that more staff in LDC2 were involved and
reciprocate physical activity planning information than in LDC1 (Table 1). Density results describe a similar pattern showing that more staff were consulted and/or reciprocated information for planning room based physical activity programs in LDC2 (73%) compared to LDC1 (55%).

Figure 2 shows the higher density of connections between staff in LDC2 compared to LDC1. A further difference between centers is the role of the center director. In LDC1, the director (node A) is an isolate, representing that the LDC1 director is not involved in providing information for planning room based physical activity programs at their center. In contrast, the director of LDC2 had relationships with respondents in that center either in the reciprocal provision of information (3 other staff) or a one-directional relationship (4 staff).

LDC1 had higher degree centralization scores for the provision of physical activity information (out-degree: LDC1 56%; LDC2 45%; in-degree: LDC1 42%; LDC 12%) and consultation (out-degree: LDC1 50%; LDC2 31%) indicating more concentration of activity for consultation and sharing.
Table 2: Individual betweenness centrality scores for “provision of information” networks.

<table>
<thead>
<tr>
<th>Job title</th>
<th>Activity planning information</th>
<th>Dietary information</th>
<th>Policy information</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LDC1</td>
<td>LDC2</td>
<td>LDC1</td>
</tr>
<tr>
<td>A Director</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>B Age 3–5 carer</td>
<td>8</td>
<td>6</td>
<td>0</td>
</tr>
<tr>
<td>C Age 2-3 carer</td>
<td>0</td>
<td>n/a</td>
<td>0</td>
</tr>
<tr>
<td>D Age 2-3 carer</td>
<td>0</td>
<td>0</td>
<td>2</td>
</tr>
<tr>
<td>E Age 0–2 carer</td>
<td>2</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>F Age 0–2 carer</td>
<td>0</td>
<td>2</td>
<td>&lt;1</td>
</tr>
<tr>
<td>G Reliever</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>H Reliever</td>
<td>0</td>
<td>2</td>
<td>0</td>
</tr>
<tr>
<td>I Reliever</td>
<td>n/a</td>
<td>n/a</td>
<td>n/a</td>
</tr>
<tr>
<td>J Cook</td>
<td>0</td>
<td>0</td>
<td>41</td>
</tr>
<tr>
<td>Mean</td>
<td>1</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>SD</td>
<td>2</td>
<td>2</td>
<td>13</td>
</tr>
</tbody>
</table>

Information in LDC1 compared to LDC2. Consultation indegree centralization scores were similarly low at both centers (LDC1 8%; LDC2 14%).

In both centers, betweenness centralization was low (both 13%), which suggests little “gatekeeping” of information between staff (i.e., one staff member “in-between” another for physical activity planning information). Negligible betweenness scores for consulting others indicate that there are no key players at either center for staff to consult regarding physical activity planning. Examining the networks for each individual staff member (Table 2) shows that betweenness centrality scores for “activity planning information” are low for all staff except the age 3–5 carer (staff member responsible for children aged 3–5, node B) at LDC1 (score of 8) and LDC2 (score of 6). This suggests that the age 3–5 carer has a more prominent role in sharing physical activity planning information compared to other staff in that center.

3.3. Dietary Information Exchange. Staff were asked which other center staff provided them with children’s dietary information (e.g., nutrition guidance, menu planning), yielding considerably different results between centers (Table 1). Density scores were almost twice as high for LDC2 (57%) than LDC1 (29%), suggesting less sharing of dietary information between pairs of staff at LDC1 compared to LDC2. Density scores for the level of decision making (LDC1 88%; LDC2 86%) and consultation (e.g., for menu planning) (LDC1 55%; LDC2 73%) suggest that menu planning is a consultative process amongst most staff. Degree centralization scores reveal the role of providing dietary information for staff at the centers as highly centralized: more so for LDC1 (out-degree 80%; in-degree 66%) than LDC2 (out-degree 49%; in-degree 49%). High dietary information betweenness centralization scores (LDC1 73%; LDC2 49%) indicate key staff having a prominent role in sharing of dietary information. Betweenness scores for dietary decision making (LDC1 4%; LDC2 6%) and consultation (LDC1 12%; LDC2 1%) were relatively low by comparison reinforcing the notion that key individuals led the center’s around food quality. Individual betweenness scores for the center cooks (node J) were very high in both centers (LDC1 41; LDC2 21) relative to all other staff (LDC1 0–2; LDC2 0–3), indicating that the cook has a prominent role for providing dietary information within the centers (Table 2). Yet the difference in scores between center cooks is considerable, the LDC1 cook having almost twice the score as the cook at LDC2. Figure 3, providing a visual depiction of dietary information networks, highlights the greater degree of centralization at LDC1 compared to LDC2, shown by the (unequal) star like structure with the cook (node J) quite central.

3.4. Policy Information Exchange. Staff were asked to indicate who provides them with policy information relevant to their role from within and external to their individual center. A large difference in density scores indicates more sharing of policy information between staff at LDC2 (68%) compared to LDC1 (31%). The provision of policy information is highly centralized reflected in higher centralization scores, particularly in LDC1 (out-degree 78%; in-degree 50%) compared to LDC2 (out-degree 37%; in-degree 37%). Despite the large difference in density and degree centralization scores between centers, betweenness centralization scores were both similar and relatively high at both centers (LDC1 45%; LDC2 43%). Individual betweenness scores suggest that the leader on policy information differs between centers. In LDC1, the center cook is highly centralized, having a high betweenness score (26%) regarding policy information compared to other staff (0–5%) and the LDC2 cook (0%). In LDC2, the director has a high betweenness score (18%) within a denser more reciprocated network, compared to all other staff at their center (0%) and the LDC1 director (0%).

3.5. External Sources of Policy Information. Responses also differed between center staff regarding key external sources of policy information (Figure 4). The regional childcare coordinator (node K) was the only external source identified
by LDC1 (by the director), whereas three staff at LDC2 identified four external sources. This included the regional childcare coordinator, identified as an external policy source by a room-based carer relatively new to the center. Two prior intervention coordinators (nodes L & M) were identified by the LDC2 director as continuing to be contacts for sourcing policy information. A fourth source was identified by an internal LDC2 relieving staff member who acknowledged external relieving staff (node N) as their information source.

4. Discussion

This study aimed to determine the feasibility and usefulness of SNA for child obesity prevention within LDC by identifying childcare staff networks and key players that could potentially influence LDC obesity prevention practice. Within this pilot of two LDC centers, we found the identification and quantification of internal LDC staff networks provided insight into existing structures primed for obesity prevention practice. General communication networks were similar at both centers, yet distinct differences between specific information networks were also found to exist. This included the identification of key players for future intervention, based on ties within the network rather than formal center job title. One center cook compared to another was notably more central for dietary and associated policy information, whilst the other director was
heavily involved in all day-to-day planning operations. SNA provided a method that was easy to administer and find these distinctions, demonstrating the potential for use in future intervention planning within the child care setting.

General information exchange relating to dietary and activity planning within each center was found to be frequent, relevant, and highly reciprocated between staff. These decentralized dense information structures suggest strong potential for effective dissemination of any new information entering the networks. Information exchange (bidirectional), as differentiated from information transfer (unidirectional), is argued to be more effective in communicating health practice and producing action [28].

We found notable differences in management involvement in day-to-day operations between centers, particularly for planning aged-based physical activity programs. Centers within Australia require national childcare quality guidelines [24] to be adopted for planning individual age/development appropriate children's programs. Within the US, although childcare is heavily regulated, physical activity (and dietary) guidelines have been found to vary between states [7]. Few centers in Australia have trained staff or policies in relation to physical activity [29]. Encouraging physical activity by training staff and following written policy are areas where centers can improve obesity prevention best practice [30]. LDC centers within the current study benefited from their prior intervention involvement as this encouraged the incorporation of childcare quality guidelines into center practice through staff training in fundamental movement skills and the design of structured active play programs tailored to each center [25].

This suggests that promoting and implementing physical activity practice in childcare are more than policy, requiring flexibility, training and guidance, and the consideration of differences in management styles and guideline interpretation. SNA provides an easy to use method to identify differences in existing networks. This could be used to tailor future health promotion training and team capacity building to these different social dynamics. In other words, more emphasis on some topics than others in some centers and interrogation of why some people are more or less the “go to” people on particular topics.

The center cook was found to play a key role regarding dietary information. Betweenness centrality revealed one cook as more prominent than the other despite both cooks having similar tenure at their respective centers and both centers previously receiving and implementing the same nutrition intervention. An implication of this finding is the possibility for using SNA within intervention planning to locate strategic personnel as program “champions” for training and disseminating health promotion information [22]. A US study of the relationship between childcare workers knowledge, beliefs, and practices stressed the importance of childcare staff having a role in nutrition education for promoting healthy eating and obesity prevention [31]. It seems childcare staff would be receptive; a UK study found enthusiasm in childcare workers to provide healthy food within centers in need of nutrition policy and staff training [32]. In this sense, the findings of our study are not unique. Cooks and program directors are obvious key players in nutrition policy and practice. But it is unique to start to build metrics around the capacities of centers (operationalized here as the densities of the relationships) and the centrality scores of key people. SNA provided further insight within these key positions, demonstrating that individuals holding the same center job title may not play the same strategic role.

The SNA highlighted different policy information networks between centers where the cook was prominent in one center as a program champion for nutrition. In contrast, the director of the other center demonstrated stronger policy links with external networks. Previous studies of social networks in healthcare teams have suggested that external networks are important for collecting and disseminating information, whilst internal structures are important for knowledge sharing [21]. Applying this perspective to the LDC findings suggests that SNA successfully identified an LDC director having a highly strategic position to promote obesity prevention practice both within the center and the broader early years community.

We also found internal LDC networks with ongoing connections to extended networks as sources of policy information. These included prior intervention coordinators and external relieving staff. A recent multisite afterschool care study found high levels of skill transfer between staff (77%), even in networks with low program connection density (2%), concluding that informal networks are potentially underutilized in this setting [33]. Our findings also suggest that there is potential to explore the extent of external network influence not only as sources of knowledge but also in sharing skills and knowledge between centers. We used SNA to look at existing networks where obesity prevention intervention had previously been implemented and found evidence of strong relational structures and practices supporting best practice in dietary management and physical activity programming within the centers. This suggests that prior intervention was instrumental in the creation of additional external networks (as continuing sources of policy information), promoting obesity prevention practice. A pediatric obesity prevention intervention found the creation of new social networks a critical outcome, highlighting the potential for sharing health behavior knowledge and practice amongst mothers of preschool aged children [34]. Using SNA to identify the creation of new ties, in addition to understanding existing network dynamics, could be imperative for understanding intervention effects.

A limitation of this study was the small sample, restricting generalizability of findings to the two day care centers involved. A study strength was the ease of using social network analysis to identify existing networks and key staff within each LDC. We examined healthy eating and physical activity information networks. This study did not examine the relationship between the networks identified and specific action to prevent obesity nor did it consider outcomes such as children's anthropometric measurement and the association with network structure. Future research should investigate how network structure impacts upon obesogenic/healthy childcare environments and children's health and weight status.
5. Conclusion

This study demonstrated the feasibility and relevance of SNA for identifying existing communication networks and strategic staff for promoting obesity prevention practice within the LDC setting. SNA represents a potentially valuable tool for understanding LDC network structures and identifying important players for tailoring intervention planning and building team capacity relevant to each LDC context.

Conflict of Interests

The authors declare that there is no conflict of interests to disclose.

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References


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