Association of Overweight/Obesity in the Development of Physical Aggression in Children and Adolescents

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Doctor of Psychology (Forensic)
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I am the author of the thesis entitled Association of Overweight/Obesity in the Development of Physical Aggression in Children and Adolescents

submitted for the degree of Doctor of Psychology (Forensic)

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Finally, I thank my beloved dog and best friend of 15 years, Chyler, who passed away a week before the submission of this thesis. Thank you for being my constant companion throughout this degree, and you will live on forever in my heart.
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<thead>
<tr>
<th><strong>Glossary of terms</strong></th>
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<tr>
<td><strong>Aggression</strong></td>
<td>Refers to physical aggression (unless otherwise specified), and encompasses behaviour causing physical harm towards others, such as hitting, punching, biting, kicking, or injuring with a weapon.</td>
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<tr>
<td><strong>Body Mass Index (BMI)</strong></td>
<td>A value derived from dividing the weight of an individual in kilograms by the square of the height in metres, and is an internationally recognised measurement for classifying overweight and obesity in children, adolescents, and adults</td>
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<tr>
<td><strong>Overweight</strong></td>
<td>Defined as having a BMI of equal to or more than 25, but less than 30</td>
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<td><strong>Obese</strong></td>
<td>Defined as having a BMI of 30 or more</td>
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Abstract

The aim of this thesis was to identify whether a significant independent association existed between overweight/obesity and physical aggression in children and adolescents aged ten to fourteen years, after controlling for various known risk and protective factors of both overweight/obesity and physical aggression. While there is an abundance of literature examining both childhood/adolescent obesity and physical aggression as independent concepts, there is scant research focussing specifically on the relationship between these outcomes, and there has been very little published research examining the association. In light of the negative developmental implications for children and adolescents who are overweight/obese or whom engage in physically aggressive behaviour, further theoretical research and empirical studies are needed in order to inform treatment targets for intervention.

Three studies were undertaken which form part of this thesis. The first study was a meta-analysis incorporating data from 23 studies comprising of a total sample size of 255,377 participants (aged 4-17 years) across a diverse range of ethnicities (Caucasian, Asian, Middle Eastern, European, Pacific Islander, and Scandinavian).

The second and third studies undertaken utilised data collected as part of the Healthy Neighbourhoods Project, a cross-sectional survey that sampled school students across three states in Australia: Victoria, Queensland, and Western Australia. Approximately 8,256 students participated in the survey.

The second study examined the association between overweight/obesity and physical aggression in childhood/adolescence utilising an Ecological Systems Theory framework, and controlled for shared risk factors, such as impulsivity, alcohol/tobacco/other drug use, depressive symptoms, television use, computer use/video game play, junk food/sugar
consumption, peer victimisation, and neighbourhood disadvantage. Results demonstrated that a significant association between overweight/obesity and physical aggression remained, despite controlling for the shared risk factors.

The third study built on the findings from the second study, and incorporated not only the risk factors that were significantly associated with physical aggression in the second study, but also a range of shared factors known to be protective against both overweight/obesity and physical aggression in children and adolescents, such as emotion control, coping skills, parental attachment, family connectedness, school attendance, and school engagement. Results demonstrated that a significant association between overweight/obesity and physical aggression remained, despite controlling for the shared risk and protective factors.

Findings from this thesis demonstrated that a significant association between overweight/obesity and physical aggression remained even after controlling for a range of shared risk and protective factors. The findings are explained through ecological, evolutionary, and social dominance theories. Some protective factors in the third study were found to reduce the strength of the association between overweight/obesity and physical aggression, suggesting that the ecological systems in place around a child/adolescent’s environment can influence whether an overweight/obese child/adolescent will engage in physical aggression, despite the association remaining overall significant. Evolutionary and social dominance theories that posit that physical aggression provides functional advantage in competition with peers for possessions, social standing, or mates are provided further support by the overall findings of the studies.
Chapter 1: The problem of overweight/obesity and physical aggression in children and adolescents

Existing child and adolescent developmental research suggests that late childhood and early adolescence is a transitional life phase that is associated with high levels for two major health conditions: overweight/obesity co-occurring with mental health problems (Hoare, Skouteris, Fuller-Tyszkiewicz, Millar, & Allender, 2014); and engaging in physically aggressive behaviour. Physical aggression (hereinafter referred to as ‘aggression’) is distinct from other types of aggression (e.g. verbal or cyber aggression) based on its specific developmental trajectory and its association with psychopathology (Barker et al., 2007). Aggression in children and adolescents can be a precursor to a variety of developmental issues, such as physician diagnosed general physical health problems (Bor, Dean, McGee, Hayatbakhsh, & Najman, 2010), mental health problems (such as mood, anxiety, psychotic disorders) (Fergusson & Woodward, 2000; Samuelson, Hodgins, Larsson, Larm, & Tengstrom, 2010), and participation in criminal activity (Fergusson & Woodward, 2000; Samuelson et al., 2010).

Nationally representative large-scale studies in Australia and the United States have indicated that the proportion of children and adolescents (aged 12 to 18 years) who engage in physically aggressive behaviour range from 18% to 33% (Bond, Thomas, Toumbourou, Patton, & Catalano, 2000; Eaton et al., 2012; Vassallo et al., 2002; Williams, Toumbourou, Williamson, Hemphill, & Patton, 2009). The 2006 Healthy Neighbourhoods Project surveyed more than 8,000 year 6 and year 8 students in 30 communities across Victoria, Queensland, and Western Australia (Williams et al., 2009), and found that up to 28.1% of year 6 males and up to 30% of year 8 males had engaged in some form of extreme violent behaviour in the previous twelve months.
Among the most consistent findings in longitudinal studies of children and adolescents is evidence of stability in levels of aggressive behaviour during early childhood and the relationship of aggression in childhood with later delinquency and substance use (Harachi et al., 2006).

Youth crime places a significant economic burden on the criminal justice system. For example, in 2011-12, the total cost of juvenile justice services across Australia was $640 million (Australian Institute of Criminology, 2015), which only included the costs associated with juveniles held in detention, community corrections, and juveniles involved in group conferencing (Australian Institute of Criminology, 2015). This figure, once again, does not represent the true cost of youth crime. Costs associated with: undetected youth crime and violence for victims and perpetrators, alternative dispute resolution; consumer affairs including consumer protection relating to criminal conduct; offender assistance expenditure; and victims of crime (such as medical/psychological treatment, costs due to lost output, property losses, and other intangible costs) have not been included in this figure (Australian Institute of Criminology, 2015).

In addition to the host of negative effects that may manifest for perpetrators of aggression, the effect on victims of that aggression can be equally devastating. Studies have demonstrated that victims of aggression in childhood and adolescence are more likely to suffer from mental health problems such as depressed mood (including loneliness and feelings of worthlessness (Bierman, Kalvin, & Heinrichs, 2015) and suicidal ideations and attempts (Hertz, Jones, Barrios, David-Ferdon, & Holt, 2015; Romo & Kelvin, 2016). Victims are also more likely to experience difficulties with making friends or getting along with peers (Bierman et al., 2015), to engage in risky sexual behaviours (Hertz et al., 2015; Romo & Kelvin, 2016), and have increased
incidence of truancy (Romo & Kelvin, 2016), to engage in physical fights or to carry a weapon to school (Hertz et al., 2015; Romo & Kelvin, 2016). Victims of aggression are also more likely to engage in tobacco use (Romo & Kelvin, 2016) or use other illicit substances (Hertz et al., 2015).

In order to prevent physical aggression it is important to identify potential triggers. One area of research that has received little attention in the literature is that of the increased occurrence of aggressive behaviour in overweight/obese children and adolescents, in comparison to their normal-weight peers. The current thesis examined whether overweight/obesity can be ruled out as a trigger for physical aggression by examining whether their association can be explained due to common developmental influences (risk and protective factors).

Overweight/obesity in children/adolescents is commonly measured using Body Mass Index (BMI), which is calculated by dividing the weight of the individual in kilograms by the square of the height in metres (Department of Health, 2009). It has been suggested that overweight/obesity in childhood and adolescence has reached global epidemic proportions, with a total of 43 million children (35 million in developing countries) estimated to be overweight or obese, and 92 million at risk of overweight in 2010 (Wang & Lim, 2012). In 2012, approximately 24% of boys and 27% of girls in Australia aged 5-17 years were classified as overweight or obese (National Health and Medical Research Council, 2013; Australian Bureau of Statistics, 2013). In the United States, childhood obesity has quadrupled in the last 30 years, with the percentage of children aged 6-11 years who were obese increasing from 7% in 1980 to nearly 18% in 2012, and the percentage of adolescents aged 12-19 years who were obese increasing from 5% to nearly 21% over the same period (Loeber, 1990; Centers
for Disease Control and Prevention, 2014). Similar figures have been identified in other parts of the world, such as in parts of Europe (Cattaneo et al., 2010; Lien, Henriksen, Nymoen, Wind, & Klepp, 2010), Scandinavia (World Health Organization, 2009), Africa (de Onis, Blossner, & Borghi, 2010), and Asia (de Onis et al., 2010).

Overweight/obesity has also been demonstrated to place great strain on a nation’s health care resources. In 2008/09, the direct financial costs to the Australian health system associated with overweight/obesity-related medical conditions (most commonly cardiovascular disease, type 2 diabetes, osteoarthritis, and a number of cancers) were estimated to be $1.3 billion (Medibank Health Solutions, 2010). These included costs associated with running hospitals and nursing homes, General Practice (GP) and specialist services, the cost of pharmaceuticals, provision of allied health services, and other direct costs (such as health administration) (Access Economics, 2008). Additional direct costs are associated with productivity losses. These are measured in terms of the impact of being absent from work, being less productive at work, and loss of productivity due to premature mortality caused by obesity-related conditions. The total cost of overweight/obesity-related conditions to the Australian economy in 2008/09 incorporating direct costs ($1.3 billion), indirect costs ($6.4 billion), and burden of disease costs ($30 billion) was estimated at $37.7 billion (Medibank Health Solutions, 2010).

Overweight/obesity in childhood or adolescence also carries with it many health risks. For example, in the short term there are increased risks of developing secondary physical health conditions including: sleep apnoea, breathlessness on exertion and/or reduced exercise tolerance, some orthopaedic and gastrointestinal problems, and non-alcoholic fatty liver disease (National Health and Medical Research Council, 2013).
Longer term there are risks of a wide range of serious health complications and premature onset of illnesses in adulthood. These include: cardiovascular disease, insulin resistance (often an early sign of impending diabetes), musculoskeletal disorders (especially osteoarthritis – a highly disabling degenerative disease of the joints), as well as some cancers (such as endometrial, breast and colon) (World Health Organization, 2014).

In addition to physical ailments, overweight and obese children and adolescents also frequently experience co-occurring psychological and behavioural problems. It remains unclear how these are associated. Potential risk factors to be explored include being subject to discrimination, bullying and teasing by their peers (National Health and Medical Research Council, 2013; Griffiths, Wolke, Page, Horwood, & the ALSPAC Study Team, 2006; Hayden-Wade et al., 2005; Sawyer et al., 2006). Of particular concern is the fact that childhood obesity co-occurrence with psychological and behavioural problems tends to track into adulthood (Magarey, Daniels, Boulton, & Cockington, 2003). As such, it is clear that the prevention of obesity and mental health disorders during childhood and adolescence should be a worldwide public health priority.

Much of the research involving overweight and obese children and adolescents has been aimed at interventions targeting physical health. Although more limited, there have also been some investigations into associations between being obese or overweight (obesity/overweight) and having mental health and/or behavioural problems in childhood or adolescence. For example, a number of studies have explored associations between body mass index (BMI) and: psychological adjustment in children (Banis et al., 1988); interactions with peers (Baum & Forehand, 1984; Gallup & Wilson, 2009;
Zeller, Reiter-Purtill, & Ramey, 2008); generalised behaviour problems and bullying
behaviour (Datar & Sturm, 2004; Griffiths et al., 2006; Janssen, Craig, Boyce, &
Pickett, 2004); health-risk behaviours (Berg, Ringqvist, & Simonsson, 2005; Farhat,
Iannotti, & Simons-Morton, 2010; Halfon, Larson, & Slusser, 2013; Pasch, Nelson,
Lytle, Moe, & Perry, 2008); and internalising and externalising behaviours
(Eschenbeck, Kohlmann, Dudey, & Schuerholz, 2009; Hwang et al., 2006; Lumeng,
Gannon, Cabral, Frank, & Zuckerman, 2003; Luukkonen, Räsänen, Riala, & Hakko,
2011; Mustillo et al., 2003; Piko, Keresztes, & Pluhar, 2006; Pitrou, Shojaei, Wazana,
Gilbert, & Kovess-Masféty, 2010; Sawyer et al., 2006; Seyedamini, Malek, Ebrahimi-
Mameghani, & Tajik, 2012).

Whilst a number of studies have found a significant relationship between
overweight/obesity and aggression (Banis et al., 1988; Baum & Forehand, 1984; Berg et
al., 2005; Datar & Sturm, 2004; Eschenbeck et al., 2009; Griffiths et al., 2006; Halfon et
al., 2013; Hwang et al., 2006; Ikaheimo et al., 2007; Janssen et al., 2004; Liu, Chen,
Yan, & Luo, 2016; Lumeng et al., 2003; Piko et al., 2006; Pine, Cohen, Brook, &
Coplan, 1997; Pitrou et al., 2010; Raine, Reynolds, Mednick, Venables, & Farrington,
1998; Reyhani & Bozorgi, 2016; Seyedamini et al., 2012; ter Bogt et al., 2006;
Tremblay et al., 1998; Zeller et al., 2008), others have found no such association (Farhat
et al., 2010; Gallup & Wilson, 2009; Luukkonen et al., 2011; Pasch et al., 2008; Pitrou
et al., 2010). Analyses relating to any gender differences have also yielded inconsistent
results. Some studies that collected data for both boys and girls have found a significant
relationship between overweight/obesity and physical aggression in girls, but not boys
(Datar & Sturm, 2004; Janssen et al., 2004), whilst others have found a significant
relationship between overweight/obesity and physical aggression in boys but not girls
Research investigating a potential link between overweight/obesity and physical aggression in children and adolescents is important, given the well-established literature on negative long-term developmental outcomes for young people who engage in physically aggressive behaviour. Much of the research literature provides evidence that during particular transition periods (such as between primary and secondary school, or at the beginning of a new school year), incidences of aggression increase while social hierarchy and status is established, but stabilises and decreases in due course (Pellegrini & Long, 2003; Pellegrini et al., 2007). In contrast, however, a number of early longitudinal studies have found that aggression remains relatively stable over time (Huesmann, Eron, Lefkowitz, & Walder, 1984), and more recent studies have yielded similar results (Herrenkohl, Catalano, Hemphill, & Toumbourou, 2009). In fact, some researchers have argued that physically aggressive behaviour, if left to continue, can worsen over time and result in escalating behaviours which can lead to criminal acts such as assault (Broidy et al., 2003; Miller, Malone, & Dodge, 2010).

Evolutionary and Social Dominance theories have attempted to explain the link. The premise of evolutionary theories rest on the fact that human survival relies on reproductive success, and that engaging in any risky behaviours will depend on weighing up the costs and benefits (Ellis et al., 2012). Adaptation in an evolutionary context does not necessarily equate to reproductive success in a direct path, but can result in reproductive success indirectly through achieving more tangible goals such as through accumulation of food, safety, status, and optimal parental investments (Ellis et al., 2012) through use of force, via physically aggressive means, which provides an efficient strategy of quickly achieve these goals for those who are of a larger body size.
Additionally, evolutionary theories posit that aggression in childhood and adolescence may have an evolutionary and adaptive function (Kolbert & Crothers, 2003; Volk, Camilleri, Dane, & Marini, 2012; Williford, Brisson, Bender, Jenson, & Forrest-Bank, 2011), and that stressful environments promote adaptation by enhancing the development of coping strategies under stressful conditions (Ellis et al., 2012). This perspective differs from some traditional social theories that suggest aggression is either a result of imitating aggressive role models, or is due to a deficit in social skills and social information processing (Crick & Dodge, 1994; 1999). Evolutionary theories emerge from studies that find children who are aggressive do not seem to necessarily lack social understanding (Sutton, Smith, & Swettenham, 1999). Contraindicating evolutionary theories are observations that aggression tends to be associated with factors that engender maladaptation, such as low socioeconomic status (Berger, 2007) and poor parent-child relationships (Veenstra, Lindenberg, Munniksma, & Dijkstra, 2010; Volk, Craig, Boyce, & King, 2006).

While it may appear that child/adolescent physical aggression can have some adaptive functionality according to evolutionary theorists in terms of maximising survival within a high-stress or dangerous environment in the short-term, this is unlikely to be beneficial for the individual in the long-term, given the negative impact on developmental trajectories of young people who engage in physically aggressive behaviours (Ellis et al., 2012). Being subjected to harsh environments where physical aggression is commonplace and perhaps necessary for survival can result in long-term harm or death, and adaptation to such conditions still constitutes a risky coping strategy that consistently places the individual’s health (both physically and psychologically) in constant jeopardy, resulting in detrimental long-term outcomes for the overall
development of the individual and has negative impacts for the welfare of the wider society (Mulvihill, 2005; Shonkoff, Boyce, & McEwen, 2009).

Within social dominance theories, overt bullying is defined as a specific form of aggression that is used deliberately in order to secure resources. In this regard, it is an example of proactively planned aggression and distinct from aggression that is used reactively, or aggression that is used in response to social provocation (Dodge & Coie, 1987). Logically, an individual who is overweight/obese would be larger in physical size and possess a greater ability to dominate their smaller peers physically.

Whilst sharing similar basic premises, Evolutionary and Social Dominance theories have some differences. Evolutionary theories propose that in some cases aggression provides a basic functionality in offering solutions to particular adaptive problems associated with some social interactions. Examples may include competition with same-sex rivals over status and access to resources and mates. By increasing costs for rivals, aggression may translate into competitive benefits for the perpetrator (Gallup, O’Brien, & Wilson, 2011). Evolutionary theories also posit that relatively common forms of aggressive behaviour exist because they have provided some competitive advantage. Benefits may occur either in terms of intra-species or inter-species competitive advantages. The adaptive value of inter-species aggression is readily apparent in animals, where aggression is used to provide access to resources such as nutrition, and for defence against predators (Kolbert & Crothers, 2003).

According to social dominance theories, aggression may be functional where it offers physical protection for individuals and through their reputation that increases their dominance within a hierarchy. Aggression is functional from this perspective as a means of gaining social allies, that offer protection from further conflicts and aggression.
from others, through a reputation that reduces the likelihood of aggressive challenges (Archer & Benson, 2008).

Social dominance theories also propose that in some contexts aggressive individuals may also develop reputations that are attractive to members of the opposite sex. From a reproductive standpoint, attributes such as physical strength, dominance, possession of material resources may become associated with male physical attractiveness. From an evolutionary perspective these attributes reference a male’s ability to provide and protect for a mate, as well as to provide a female with good genes to pass onto offspring (Archer & Benson, 2008).

Social dominance theory extends evolutionary theories by application to a modern and co-operative context, in which dominant behaviours may be elevate social hierarchy and prestige relative to peers in accordance with their access to socially important resources (Kolbert & Crothers, 2003; Walcott, Upton, Bolen, & Brown, 2008). Dominance in humans, often referred to as power relations, is also likely to incorporate verbal altercations as well as physically aggressive strategies, which are designed to assist with achieving and maintaining favour and higher status amongst peers (Kolbert & Crothers, 2003; Walcott et al., 2008). Acts of dominance can be observed in those as young as preschool and primary school aged children, where there may be competition for access to toys and other play-related materials as well as for peer attention (Smith & Connolly, 2010). Resources that require competition for adolescents may be related to the gaining the favour of peers and potential sexual partners, as this life-stage marks the beginning of sexual maturity and activity (Brooks-Gunn & Furstenberg, 1989). Developmental research also indicates that the physical and emotional changes that occur during early adolescence increase the likelihood that youth may act aggressively
toward their peers (Pellegrini & Long, 2002). Youths’ bodies are changing rapidly during this period, with the inclusion of changes in hormone levels, body size, and sexual maturity all coinciding with increased interest in attracting romantic partners (Pellegrini & Bartini, 2001). Such a rapid change in body size may lead to the reorganisation of social dominance hierarchies, particularly in males (Hawley, 1999; Pellegrini & Bartini, 2001). Bigger and stronger children or adolescents become more dominant than their smaller peers, and this in turn, is related to their attractiveness to peers and potential sexual partners (Pellegrini & Bartini, 2001).

The transition from childhood and primary school to puberty and middle school also typically corresponds to children moving from small schools with well-established social hierarchies into different and larger peer groups (Pellegrini & Long, 2002). For many students the transition to middle school is an abrupt change from an environment in which they were viewed as powerful and influential to one that affords them relatively low status (Pellegrini & Long, 2002). Consequently, status in these new settings, including dominance, must be redefined at the same time that peer affiliation is particularly important (Simmons & Blyth, 1987), and early adolescence therefore marks not only a time of physical maturation and interest in sexual relationships, but also a strong desire to be accepted by friends and peers (Adams & Bukowski; Pellegrini & Long, 2002; Williford et al., 2011).

Advocates of social dominance theory argue that youth in early adolescence use a variety of interpersonal and social resources to influence classmates in order to achieve peer group status (Adams & Bukowski; Parkhurst & Hopmeyer, 1998). Selective use of aggression in such contexts may play an important role in the establishment of social standing in peer groups (Kolbert & Crothers, 2003). Children start to form peer groups
when they are of preschool age, and become more selective in their choice of friends as they mature (Kolbert & Crothers, 2003). Hierarchical social structures emerge as some students and groups gain prominence and influence over other students and groups (Kolbert & Crothers, 2003). Beginning in primary school, students begin to engage in interpersonally aggressive behaviour in order to protect and improve their social positions, and popular students manipulate and use aggressive behaviour to publicly assert their superiority over others (Farmer & Cadwallader, 2000). According to this perspective, dominant individuals would initially use aggression to compete for resources, thereby establishing and maintaining dominance hierarchies (Savin-Williams, 1979). Once established a lead position may then result in greater access to social or material resources that give the power to influence, persuade, or compel others, and to enhance their own access to further resources (Closson, 2009; Hawley, 1999). Various studies have supported this hypothesis, and have found that relative to their subordinate peers, socially dominant youths have been characterized as more influential, daring, physically attractive, and socially appropriate; thus, they are often perceived as attractive social partners and are afforded high status (Hawley, 1999; Savin-Williams, 1979).

In addition to the Evolutionary and Social Dominance theories, Ecological Systems Theory (EST) (Bronfenbrenner, 1979) may also offer some insight into the link between overweight/obesity and aggression. This model posits that risk factors associated with aggression in childhood and adolescence occur at many levels and include individual factors, environment factors and their interactions. The model provides a comprehensive and broad conceptual approach that seeks to specify how multiple factors can influence health behaviour (Lin, Chang, Luh, Hurng, & Yen, 2014). Ecological Systems Theory
(EST) posits that the development of an individual is influenced by not only individual characteristics (such as gender and age), but by the context and environment (or ecological niche) in which he or she is located (and therefore interacts with), which includes their family and school (Davison & Birch, 2001). Those in turn are also influenced by larger social contexts such as the community and society at large (Davison & Birch, 2001).

Research findings appear to be consistent with this multi-levelled approach. For example, studies have demonstrated that there are risk factors that have been strongly associated with both overweight/obesity and aggression in children and adolescents, which could contribute to this common relationship. Specifically, individual-level factors such as depressive symptoms (Benarous, Hassler, Falissard, Consoli, & Cohen, 2015; Harachi et al., 2006; Hoare et al., 2016; Hoare et al., 2014; Kaltiala-Heino & Frojd, 2013; Martin-Storey & Crosnoe, 2015; Piko & Pinczés, 2014; Priddis, Moroney, Kane, & Landy, 2014), substance use (including alcohol and tobacco use) (Blackstone & Herrmann, 2016; Farrant et al., 2013; Gázquez et al., 2016; Harachi et al., 2006; Kivimäki et al., 2014; Kuo, Yang, Soong, & Chen, 2002; Sacco, Bright, Jun, & Stapleton, 2015; Valdebenito, Ttofi, & Eisner, 2015; White, Fite, Pardini, Mun, & Loeber, 2013; Zeller, Becnel, Reiter-Purtill, Peugh, & Wu, 2016), impulsivity (De Decker et al., 2016; Delgado-Rico, Río-Valle, González-Jiménez, Campoy, & Verdejo-García, 2012; Fields, Sabet, & Reynolds, 2013; Fuentes, Jurado, Martinez, Rubio, & Gazquez, 2016; Pauli-Pott, Albayrak, Hebebrand, & Pott, 2010; Sarkisian, Van Hulle, Lemery-Chalfant, & Goldsmith, 2017; Thamotharan, Lange, Zale, Huffhines, & Fields, 2013), and peer-level factors such as peer-rejection/victimisation (Cooley & Fite, 2016; Jansen et al., 2014; van Geel, Vedder, & Tanilon, 2014; Wang, Duong, Schwartz,
Chang, & Luo, 2014) have been linked with both overweight/obesity and aggression. Family- and community/neighbourhood-level factors such as neighbourhood socio-economic status (SES) (MarÉEs & Peterman, 2010; Yu, Shi, Huang, & Wang, 2006) have also been found to have significant separate associations with both overweight/obesity and aggression.

There is confusion within the available literature as to whether associated factors are causes or consequences of overweight/obesity or aggression. Some studies have examined associated factors as an outcome of overweight/obesity or aggression such as: psychological symptoms (Berg et al., 2005; Eschenbeck et al., 2009; Halfon et al., 2013; Lumeng et al., 2003; Luukkonen et al., 2011; Pasch et al., 2008; Pine et al., 1997; Pitrou et al., 2010; Sawyer et al., 2006; Zeller et al., 2008), substance use (Berg et al., 2005; Farhat et al., 2010; Pasch et al., 2008), self-perception (Banis et al., 1988; Berg et al., 2005), and socio-economic status (SES) and parental education/income levels (Datar & Sturm, 2004; Farhat et al., 2010; Griffiths et al., 2006; Halfon et al., 2013; Ikaheimo et al., 2007; Lumeng et al., 2003; Pasch et al., 2008; Pine et al., 1997; Pitrou et al., 2010; Sawyer et al., 2006; Seyedamini et al., 2012; ter Bogt et al., 2006; Zeller et al., 2008).

Lumeng et al. (2003) is one of few studies that have examined the effects of obesity on aggression after controlling for the effects of gender, SES and maternal education levels. However, the child outcome variable was the Behaviour Problems Index, which includes an assortment of problematic behaviours in children in addition to measures of aggression (Lumeng et al., 2003). Hence, it remains unclear to what extent socio-demographic factors may explain the association between BMI and aggression in children and adolescents.
Whilst many studies have found a significant association between BMI and aggression, it is clear, that not all overweight/obese children and adolescents become aggressive, which suggests the presence of protective factors (sometimes called compensatory factors) that may mitigate this developmental trajectory. These terms emerge from developmental epidemiology where risk factors are defined based on consistent evidence that they predict the future onset of a specific outcome such as aggression. Protective factors are defined based on evidence that they reduce the likelihood of a future outcome amongst children with high risk factors (Lösel & Farrington, 2012).

The study of protective factors is closely linked to investigations of child resilience, and children who succeed in spite of adversity have been identified as resilient. Research seeking to identify why they were resilient identified higher levels of protective factors that helped them overcome adverse conditions (Zolkoski & Bullock, 2012). Resilience is defined as the ability of individuals to survive and thrive despite exposure to negative circumstances (Hollister-Wagner, Foshee, & Jackson, 2001). It refers to the process of overcoming the negative effects of risk exposure, coping successfully with traumatic experiences, and avoiding the negative trajectories associated with risks (Fergus & Zimmerman, 2005). Resilience theory, though it is concerned with risk exposure among adolescents, is focused on strengths rather than deficits. It focuses on understanding healthy development in spite of risk exposure (Fergus & Zimmerman, 2005).

Protective factors operate at many levels including through: extra-familial environmental processes (neighbourhood, school, peer group, community groups, community institutions), familial processes (family resources, parental characteristics,
parental behaviour/parenting), within social processes (competence, nurturing, connectedness, social responsibility), and individual characteristics (self-beliefs, health, development, cognition) (Resnick, 2000). Protective and risk factors are dynamically influenced by context (Walsh, 2003). According to Benzies and Mychasiuk (2009), resilience is optimized when protective factors are strong across the socio-ecological levels of individual, family, and community.

Studies have demonstrated that there are factors that may have protective effects against both overweight/obesity and aggression, and it is possible that these factors could influence the relationship between overweight/obesity and aggression. Specifically, research literature has indicated that protective factors for both overweight/obesity and aggression include individual-level factors such as emotional control (Aparicio, Canals, Arija, De Henauw, & Michels, 2016; Cooley & Fite, 2016; Graziano, Calkins, & Keane, 2010; Jacobson & Melnyk, 2011; Kelly et al., 2016; Polan, Sieving, & McMorris, 2013; Power et al., 2016; Tsukayama, Toomey, Faith, & Duckworth, 2010) and coping skills (Bernat, Oakes, Pettingell, & Resnick, 2012; Boggiano et al., 2015; Jääskeläinen et al., 2014; Sullivan, Helms, Kliwer, & Goodman, 2010). Protective factors for these outcomes also include school-level factors such as school connectedness and engagement (Baxter, Royer, Hardin, Guinn, & Devlin, 2011; Bethell, Simpson, Stumbo, Carle, & Gombojav, 2010; Carey, Singh, Brown III, & Wilkinson, 2015; Duggins, Kuperminc, Henrich, Smalls-Glover, & Perilla, 2016; Echeverría, Vélez-Valle, Janevic, & Prystowsky, 2014; Fontaine, Brendgen, Vitaro, Tremblay, & Richard, 2016; Li et al., 2012; Rappaport, Daskalakis, & Andrel, 2011; Resnick, Ireland, & Borowsky, 2004; Richmond, Milliren, Walls, & Kawachi, 2014; Simons-Morton, Hartos, & Haynie, 2004; Smokowski et al., 2017; Voisin & Elsaesser,
and family-level factors such as family connectedness (Bernat et al., 2012; Dubow, Huesmann, Boxer, & Smith, 2016; Duggins et al., 2016; Halliday, Palma, Mellor, Green, & Renzaho, 2014; Hooper et al., 2014; Jia, Wang, Shi, & Li, 2016; Kramer-Kuhn & Farrell, 2016; Lin et al., 2014; Resnick et al., 1997; Resnick et al., 2004; Rutter, 1985; Shlafer, McMorris, Sieving, & Gower, 2013; Simons-Morton et al., 2004; Smokowski et al., 2017; Taylor, Merrilees, Goeke-Morey, Shirlow, & Cummings, 2016), and parental attachment (Hooper et al., 2014; Kapoor & Tung, 2017; Keitel-Korndörfer et al., 2015; Maras et al., 2016; Murphy, Laible, & Augustine, 2017; Resnick et al., 2004; Smokowski et al., 2017; Taylor et al., 2016).

**Rationale for Further Study**

The studies in this thesis sought to contribute to establishing the extent to which overweight/obesity is a predictor of aggression in children and adolescents, after controlling for common risk and protective factors. Neither a systematic review nor a meta-analysis of the existing literature relevant to the relationship between overweight/obesity and aggression in children and adolescents has been previously published. Hence, the first study sought to complete a literature review and meta-analysis of the available evidence to ascertain whether an association exists between overweight/obesity (as measured by Body Mass Index (BMI)) and physical aggression in children and adolescents. Empirical studies examining potential risk and protective factors that are common predictors of overweight/obesity and aggression in children and adolescents have been lacking. Hence, the current thesis also sought to complete studies of this type.

Given the long-term negative consequences for children and adolescents who are overweight/obese or whom engage in aggressive behaviour, further and more in-depth
research is needed in order to inform treatment targets for intervention. The implications of research that can further identify the relationship between obesity/overweight and aggressive behaviour is that it can inform potential early intervention and preventive approaches. Examining both risk and protective factors, can identify not only individual, but also school- and family-related factors in an effort to reduce the influence of overweight/obesity on the development of aggression.

Firstly, given the inconsistent findings in the current literature, a meta-analysis assessing whether a relationship indeed exists between overweight/obesity and aggression in children and adolescents was conducted (Chapter 3). Since significance testing is highly dependent on sample size, it is important to identify effects across pooled samples in order to synthesise findings from prior studies. As a significant association was identified, a set of empirical studies utilising a large, representative sample were conducted as reported in later chapters in order to ascertain the influence that both risk and protective factors may have on the relationship between overweight/obesity and aggression in children and adolescents. It was expected that a significant association would remain between overweight/obesity and physical aggression in the same utilised in the empirical studies, even after controlling for both shared risk and protective factors. Possible explanations for the link (if found) and implications for theory and interventions will be discussed in the General Discussion.
Chapter 2: Description of publications

This chapter describes the three studies that were conducted in order to identify gaps in the literature and improve current understanding of the association between overweight/obesity and aggression in children and adolescents.

The first study involved conducting a meta-analysis. The purpose was to identify firstly, whether there was an association between overweight/obesity and aggression, and secondly, the strength of any such association. Available research was collated, and key data synthesised. It was hypothesised that there would be a significant association between overweight/obesity (measured by BMI) and aggression.

The second and third empirical studies were then conducted, involving secondary analysis of data obtained from the 2006 Healthy Neighbours Project. This was a large-scale, cross-sectional epidemiological study conducted in 2006. The study examined the health and wellbeing of children and adolescents from 30 communities across three states in Australia: Victoria, Queensland, and Western Australia. The measures were based on the Communities that Care Youth Survey, an epidemiological assessment instrument that was developed in the United States (Arthur, Hawkins, Catalano, Pollard, & Baglioni, 2002), and adapted for Australian youth populations (Beyers, Toubourou, Catalano, Arthur, & Hawkins, 2004; Bond et al., 2000; Hemphill et al., 2010). The participants were young people in grade 6 (mean age 12 years) and grade 8 (mean age 13 years), stratified by level of socio-economic disadvantage. In both studies, student height and weight were physically measured, and cohort age, gender, and socio-economic disadvantage were controlled for in order to minimise the effects of these variables on the association between overweight/obesity and aggression.
The second study identified several risk factors common to both overweight/obesity and aggression. These included impulsivity, substance use (including alcohol, tobacco and other drug use), depressive symptoms, unhealthy food (such as junk food and sugar) consumption, peer victimisation, television use and computer use/video game play. These risk factors were controlled for in the multivariate analysis examining the effect of overweight/obesity on physical aggression.

The third study focussed on the role of protective factors as moderators and mediators of the relationship between overweight/obesity and physical aggression. The risk factors that were found to significantly impact on the relationship between overweight/obesity and physical aggression from the second study were included. In addition, a number of protective factors common to both overweight/obesity and physical aggression were examined. These included emotion control, coping skills, parental attachment, family connectedness, school attendance and school engagement. All of these factors were included in a final multivariate analysis. In what follows, this Chapter will describe in more detail the three articles that were written in order to address the aims of this thesis.


There is scant research investigating the possible association between overweight/obesity and physical aggression in children and adolescents. Some existing research have reported a link, but few studies have focussed specifically on this association. This meta-analysis aimed to identify whether there was a significant
association between overweight/obesity and physical aggression in children and adolescents (aged up to eighteen years). Potential gender differences were also examined. Results demonstrated a significant association between overweight/obesity and physical aggression. Those children and adolescents who were classified as overweight/obese were significantly more likely to engage in physically aggressive behaviour. This association remained significant for both boys and girls, with a slightly larger effect size found for boys. Implications for theory and developmental processes which may contribute to this association are discussed.

Article 2: Overweight/obesity as a risk factor for the development of physical aggression in childhood and adolescence and other contributors (Tso, M.K.W., Toumbourou, J.W. Submitted to Journal of Adolescence)

Engaging in physically aggressive behaviour in childhood and adolescence can have far-reaching negative consequences on developmental outcomes. Prior research has found support for an association between overweight/obesity and physical aggression in children and adolescents. An important gap is that prior research has not investigated whether the association between overweight/obesity and physical aggression in children and adolescents is maintained after adjusting for risk factors that are common to these two areas. This study investigated the association between overweight/obesity and physical aggression utilising a large (N = 7,280) representative sample of Australian children. The aim of the study was to investigate whether the association would be maintained after controlling for shared risk factors. It was hypothesised that an independent relationship between overweight/obesity and physical aggression would exist, even after controlling for common risk factors. The second hypothesis was that the common risk factors would remain significantly associated with
aggression in the multivariate analysis. The results supported the first hypothesis, and partially supported the second. Socio-economic disadvantage, peer victimisation/rejection, and television use were no longer significantly associated with aggression in the adjusted multivariate model. Explanations for and implications of these findings for early intervention are discussed.

**Article 3: Protective factors modifying the association between overweight/obesity and physical aggression in children and adolescents (Tso, M.K.W., Toumbourou, J.W., & Williams, J., submitted to Journal of Research on Adolescence)**

Little research has investigated factors that may contribute to an association between overweight/obesity and physical aggression in children and adolescents. This gap is partly addressed in Article 2 (Chapter 5), with this association being investigated while controlling for demographic variables and common risk factors for both overweight/obesity and physical aggression. This study builds on the findings of Article 2, by extending the multivariate analysis to include a range of factors known to be protective against both overweight/obesity and physical aggression in children and adolescents. The multivariate analysis model included the common risk factors that were found to be significantly related to physical aggression from Article 2 in addition to the protective factors. It was hypothesised that an independent relationship between overweight/obesity and physical aggression would exist even after controlling for the risk and protective factors. The second hypothesis was that the protective factors would remain significantly associated with physical aggression in the multivariate analysis. Results provided support for the first hypothesis and partial support for the second hypothesis. Socio-economic disadvantage and computer use/video game play were no longer significantly related to physical aggression in the multi-variate model. The main
effects of coping skills and school engagement with physical aggression were not
significant, though both of these factors yielded significant interaction effects with BMI
(the measure of overweight/obesity). Explanations for, and the implications of, these
findings for early intervention are discussed.
Chapter 3: Article 1: Overweight or obesity associations with physical aggression in children and adolescents: A meta-analysis


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Bosco Rowland¹Ph.D
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### Authorship Statement

#### 1. Details of publication and executive author

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| Overweight or obesity associations with physical aggression in children and adolescents: A meta-analysis | International Journal of Behavioral Development  
Doi: 10.1177/0165025417690265 |

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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.)

Conducted the literature search, contributed to the conception of the study and the planning of the analysis, contributed to statistical analysis, contributed to data interpretation and drafted the full manuscript and incorporated the revisions of the other 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

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| **Bosco Rowland**  
Deakin University, Melbourne, Victoria, Australia | Contributed to planning, conception of the study, conducting and interpreting the statistical analysis, redrafting and critical revision of the manuscript |
| **John W. Toumbourou**  
Deakin University, Melbourne, Victoria, Australia; Centre for Adolescent Health, the Royal Children’s Hospital, Melbourne, Victoria, Australia | Principal Investigator, Victoria for the 2006 Healthy Neighbourhoods Project (cross-sectional study that provided data for this study); contributed to the conception of the study, planning, conducting and interpreting the statistical analysis, redrafting and critical revision of the manuscript |
| **Belinda L. Guadagno**  
Deakin University, Melbourne, Victoria, Australia | Contributed to planning; redrafting and critical revision of the manuscript |

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Abstract

Being overweight or obese (overweight/obesity) or physically aggressive in childhood and adolescence can have lifelong consequences, hence are important public health problems. Identifying a relationship between these problems would assist in understanding their developmental origins. The present paper sought to review previous studies and use meta-analysis to evaluate whether there is evidence of a relationship between overweight/obesity and physical aggression in children and adolescents. A systematic search of studies that reported the effect of overweight/obesity (in the form of Body Mass Index) on physical aggression was conducted. A total of 23 studies were identified, representing data from 255,377 participants. The results indicate that children and adolescents who are overweight or obese are more physically aggressive than their normal-weight or underweight peers. The average weighted standardised mean difference (the effect size) for aggression in overweight and obese children and adolescents compared to others was found to be 0.27 (95% Confidence Interval [CI95]: .17 - .37), and was significant (p < .001). Gender sub-analysis indicated that higher physical aggression amongst overweight or obese compared to normal-weight or underweight peers is a slightly larger effect for boys (standardised mean difference of .35, CI95: .18 - .52, p < .001) than girls (standardised mean difference of .24, CI95: .07 - .42, p < .01). High levels of heterogeneity (94.41%) were found between study-level effect sizes. The developmental processes that may explain the association between overweight/obesity and physical aggression in children and adolescents are discussed.

Keywords: Obesity, Overweight, Physical aggression, Bullying, Meta-analysis
Introduction

The incidence of overweight and obesity in childhood and adolescence has increased globally. In 2012, approximately 24% of boys and 27% of girls in Australia aged 5-17 years were classified as overweight or obese (National Health and Medical Research Council, 2014; Australian Bureau of Statistics, 2013). In the United States, childhood obesity has quadrupled in the last 30 years, with the percentage of children aged 6-11 years who were obese increasing from 7% in 1980 to nearly 18% in 2012, and the percentage of adolescents aged 12-19 years who were obese increasing from 5% to nearly 21% over the same period (Loeber, 1990; Centers for Disease Control and Prevention, 2014). Similar figures have been identified in other parts of the world, such as in parts of Europe, Scandinavia, Africa, and Asia (Child Obesity, 2015).

These high prevalence rates are concerning as overweight and obesity are associated with an increased risk of developing cardiovascular diseases (Dietz 2004; Centers for Disease Control and Prevention, 2014), social difficulties (such as social isolation or teasing from peers) (Daniels et al., 2005), and psychological issues (such as depression) (Daniels et al., 2005). A considerable burden is also placed on the national health care system as a result. In Australia in 2008, the total annual amount of obesity-related costs (including costs associated with loss of productivity and carers’ fees) was estimated at AUD$58 billion (Access Economics, 2008), and in the United States in the same period was estimated to be US$254 billion, including US$208 billion in lost productivity, and US$46 billion in direct medical costs (American Heart Association, 2013).

It is also possible that obesity may be linked to broader child behaviour problems, such as that of physical aggression. Physical aggression in children and adolescents can
be a precursor to a variety of developmental problems, such as general physical health problems (Bor et al., 2010), mental health problems (such as mood, anxiety, psychotic disorders (Fergusson & Woodward, 2000; Samuelson et al., 2010), and participation in criminal activity (Fergusson & Woodward, 2000; Samuelson et al., 2010). Nationally representative large-scale studies in Australia and the United States have indicated that the proportion of children and adolescents (aged 12 to 18 years) who engage in physically aggressive behaviour range from 18% to 33% (Bond et al., 2000; Eaton et al., 2012; Vassallo et al., 2002; Williams et al., 2009).

Much of the research involving overweight and obese children and adolescents has been aimed at interventions targeting physical health. Although more limited, there have also been some investigations into associations between being obese or overweight (obesity/overweight) and having mental health and/or behavioural problems in childhood or adolescence. For example, a number of studies have explored associations between body mass index (BMI) and: psychological adjustment in children (Banis et al., 1988); interactions with peers (Baum & Forehand, 1984; Gallup & Wilson, 2009; Zeller et al., 2008); generalised behaviour problems and bullying behaviour (Datar & Sturm, 2004; Griffiths et al., 2006; Janssen et al., 2004); health-risk behaviours (Berg et al., 2005; Farhat et al., 2010; Halfon et al., 2013; Pasch et al., 2008); and internalising and externalising behaviours (Eschenbeck et al., 2009; Hwang et al., 2006; Lumeng et al., 2003; Luukkonen et al., 2011; Mustillo et al., 2003; Piko et al., 2006; Pitrou et al., 2010; Sawyer et al., 2006; Seyedamini et al., 2012).

There have only been a small number of studies that have reported and investigated the possibility of an effect of being overweight or obese on physical aggression (Gallup & Wilson, 2009; Ikaheimo et al., 2007; Janssen et al., 2004; Piko et al., 2006; Raine et
Based on significance testing, it appears that the results of many studies investigating this relationship have been mixed. Some research has identified a significant relationship between being overweight or obese and engaging in physically aggressive behaviours (Banis et al., 1988; Baum & Forehand, 1984; Berg et al., 2005; Datar & Sturm, 2004; Eschenbeck et al., 2009; Griffiths et al., 2006; Halfon et al., 2013; Hwang et al., 2006; Ikaheimo et al., 2007; Janssen et al., 2004; Lumeng et al., 2003; Piko et al., 2006; Raine et al., 1998; Sawyer et al., 2006; Seyedamini et al., 2012; Tremblay et al., 1998; Zeller et al., 2008). Other studies, however, have not found a significant relationship (Farhat et al., 2010; Gallup & Wilson, 2009; Luukkonen et al., 2011; Pasch et al., 2008; Pitrou et al., 2010). Analyses relating to any gender differences have also yielded inconsistent results. Some studies that collected data for both boys and girls have found a significant relationship between overweight/obesity and physical aggression in girls, but not boys (Datar & Sturm, 2004; Janssen et al., 2004), whilst others have found a significant relationship between overweight/obesity and physical aggression in boys but not girls (Griffiths et al., 2006; Piko et al., 2006; Sawyer et al., 2006).

A number of theories have been proposed to explain why overweight/obesity may influence physical aggression in children and adolescents. These are outlined in the conceptual model in Figure 1 below.
Figure 1. Theories of how overweight/obesity influences physical aggression in children and adolescents

**Social Dominance Model**

Some authors have argued that this relationship exists in children and adolescents as a result of evolutionary utility. A social dominance perspective posits that, over time, increased height and weight resulted in reinforcement of the use of aggression as an effective strategy not only for winning social conflicts, but also the securing of material resources and mating opportunities (Gallup & Wilson, 2009; Piko et al., 2006; Raine et al., 1998; Volk et al., 2012). Gallup and Wilson (2009) further suggested that an association between overweight/obese and peer aggression may exist among females as a means to diminish the reputation and appeal of female peers, in an attempt to make other females less desirable to available males.
**Socio-economic Status (SES)**

An alternative theory holds that childhood disadvantage may be a common cause of both physical health and behavioural problems. In particular, low SES (as measured by parental income) has been found to correlate with overweight and obesity in children and adolescents (Dinsa, Goryakin, Fumagalli, & Suhrcke, 2012; Eschenbeck et al., 2009; Farhat et al., 2010; Mustillo et al., 2003; Pitrou et al., 2010; Sawyer et al., 2006; Wang & Lim, 2012; Wu et al., 2015), but only in developed countries and not in developing countries. Dinsa et al. (2012) and Wu et al. (2015) suggest that individuals of low SES from developing countries face food shortages (which prevent them from becoming overweight/obese) while those in developed countries are particularly exposed to the marketing of cheap processed, energy-dense foods (Dinsa et al., 2012; Wu et al., 2015). In developed nations, nutrient-rich low calorie foods (such as wholegrain cereals, fruits and vegetables) are less affordable for those of lower SES, which would result in the consumption of more energy-dense foods that are more affordable (such as fast foods) (Dinsa et al., 2012; Wu et al., 2015). In addition, higher degrees of urbanisation and technological progress (including increases in information dissemination) in developed nations render occupations less laborious, resulting in less energy expenditure and the leading of a more sedentary lifestyle (Dinsa et al., 2012; Wang & Lim, 2012).

A relationship between low SES and aggression in childhood and adolescence has also been identified in many studies (Datar & Sturm, 2004; Janssen et al., 2004; Najman et al., 2010; Romano, Tremblay, Boulerice, & Swisher, 2005; Santiago, Wadsworth, & Stump, 2011), though results have been mixed. Najman et al. (2010) and Santiago et al. (2011) hypothesised that young people who experience chronic family poverty would
eventually resign themselves to being unable to join a more middle-class, mainstream sector of society, and as a form of rebellion, elect to engage in delinquent, criminal, and aggressive behaviour, often with other like-minded peers. Living a healthy, non-violent lifestyle diminishes in priority as their social exclusion becomes a more evident feature of their day-to-day lives (Najman et al., 2010).

**Negative Peer Interactions: Peer rejection or peer victimisation**

An additional theory may be that overweight and obese children and adolescents experience more negative peer interactions (in the form of peer rejection or victimisation by peers) which may lead to subsequent displays of physical aggression (Berg et al., 2005). There is evidence demonstrating support for a relationship between overweight/obesity and peer rejection (Gunnarsdottir, Njardvik, Olafsdottir, Craighead, & Bjarnason, 2012) and victimisation by peers (Puhl, Luedicke, & Heuer, 2011; van Geel et al., 2014), as well as associations between physical aggression and peer rejection (Dodge & Pettit, 2003) and victimisation by peers (Ostrov, 2010; Sullivan, Farrell, & Kliwuer, 2006) in children and adolescents. Children are heavily reliant on physical cues in their social interactions and are likely to be influenced by stereotypes associated with those cues (such as, that overweight or obese individuals tease others, are teased, who fight, are selfish and mean) and subsequently behave in a manner towards other normal-weight individuals that is congruent with those beliefs and stereotypes (Janssen et al., 2004). Besides conforming with negative stereotypes about themselves, overweight youngsters may also avoid physical activities in an effort to prevent being subjected to teasing and social rejection by others (Gunnarsdottir et al., 2012), thus beginning a vicious cycle by reducing social interaction opportunities, resulting in lower social competence and lower social skills which may further
predispose them to teasing and social rejection (Gunnarsdottir et al., 2012). Children who are victimised may also learn from those interactions and may model aggressive behaviour towards others in future hostile interactions with peers, particularly if those subsequent actions are positively reinforced by being effective at reducing peer victimisation and facilitating goal attainment such as social status (Ostrov, 2010). As children enter adolescence, achieving a high social status amongst peers takes on paramount importance, and they become increasingly sensitive to stressors that are deemed humiliating or embarrassing (Sullivan et al., 2006). Simultaneously, their coping skills undergo dramatic shifts as their coping repertoire increases, whereby they acquire and use more emotion-focused coping strategies, some of which are less adaptive than others (Sullivan et al., 2006). Aggression and delinquent behaviours are sometimes used as maladaptive coping strategies in order to deal with the emotional arousal created by peer victimisation experiences (Sullivan et al., 2006).

**Mental Health Issues**

Both social disadvantage (and associated child development problems) and peer conflict can contribute to mental health problems, providing a further theory as to why overweight/obesity and physical aggression may be associated. Common mental health problems (such as depression and anxiety) have been found to correlate with both overweight/obesity and physical aggression (Sanders, Han, Baker, & Cobley, 2015). Young people suffering from anxious and depressive symptomatology may engage in more instances of ‘emotional comfort eating’ or ‘stress-induced eating’ as a form of emotional defence or as a coping mechanism (Pervanidou & Chrousos, 2011; Wilson & Sato, 2014). Wilson and Sato (2014) suggested that elevations in cortisol levels due to stress may also contribute towards stress-eating, and a common response for an
individual experiencing high levels of stress would be to seek out highly palatable
(often energy-dense, high-fat and sweet) foods to provide relief in order to diminish the
distress. Chronic stress and depressive symptomatology have also been linked to
sedentary behaviour because of reduced motivation levels to engage in daily activities
(Berg et al., 2005; Datar & Sturm, 2004; Gundersen, Mahatmya, Garasky, & Lohman,
2011; Halfon et al., 2013; Hoare et al., 2014; Korczak, Lipman, Morrison, & Szatmari,
2013; Mustillo et al., 2003; Pasch et al., 2008; Sanders et al., 2015; Seyedamini et al.,
2012; Wilson & Sato, 2014), which may result in an imbalance between energy intake
in comparison to energy expenditure, increasing the likelihood of these individuals
becoming or remaining overweight/obese (Wilson & Sato, 2014). Physical activity is
also associated with increased self-efficacy and social integration, which are skills that
are protective against symptoms of depression and anxiety (Hoare et al., 2014). Some
studies have also found a relationship between stress, anxiety and depressive
symptomatology and physically aggressive behaviour (Leschied, Chiodo, Nowicki, &
Rodger, 2008; Priddis et al., 2014; Seah & Ang, 2008), though in-depth explorations
into this link appear to be lacking. Priddis et al. (2014) allude towards difficulties with
emotion regulation in youth exhibiting these symptoms and traits, whilst Seah and Ang
(2008) point towards anxious individuals experiencing higher levels of hypervigilance
with respect to perceived hostile threats in social contexts, which then results in pre-
emptive aggressive behaviour.

**Self-Regulation Problems: Impulsive/Risky Behaviour (Including Substance Use)**

Childhood stress associated with prolonged exposure to social disadvantage, conflict
(including both within the home and amongst peers) and mental health problems has
been argued to undermine healthy neurological development, resulting in long-term
“toxic stress”, which can lead to maladaptive behavioural characteristics such as impulsivity (National Scientific Council on the Developing Child, 2005/2014; Hornor, 2015). Both overweight/obesity and physical aggression in children and adolescents are associated with problems in self-regulation indicated by impulsive and risky behaviours, such as engaging in substance use. Motivations behind engaging in impulsive and risky behaviours (including substance use) seem to centre on the increased importance of social standing within peer groups during this crucial developmental and transitional period for young people (Farhat et al., 2010; Huang, Lanza, Anglin, & Wright-Volel, 2013; Lanza, Grella, & Chung, 2014). The critical importance of a sense of belonging, in combination with a desire for peer acceptance and undergoing the development of self-regulatory processes (which are especially important for rational decision-making abilities) may increase a young person’s vulnerability towards engaging in impulsive and risky behaviours (Huang et al., 2013; Lanza et al., 2014). Early substance use may also encourage further social connections with others who engage in similar risky and impulsive behaviours which may further isolate and distance the individuals from engaging in healthy, normative influences (Pasch, Velazquez, Cance, Moe, & Lytle, 2012). These early maladaptive behaviours may serve as an early indicator of the later development of a wide array of health-risk behaviours, which include sedentary behaviours, the acquisition of poor eating habits, and other habits which may be detrimental towards health (Pasch et al., 2008). Those who have difficulties with self-control and exhibit poor emotion regulation abilities (including anger regulation) may also be more likely to over-consume energy-dense food, which would contribute to an increased overweight/obesity risk (Harrist, Hubbs-Tait, Topham, Shriver, & Page, 2013; Lanza et al., 2014). Reverse effects have also been found in some studies, as increased
alcohol intake can have an effect on energy balance and could lead to weight gain over time, or dull incentives to be physically active (Pasch et al., 2012). Aside from over-consumption of energy-dense food, associations have also been found between impulsive and risky behaviours and engaging in physically aggressive behaviours (Mercado-Crespo & Mbah, 2013; Moore et al., 2014; Piko et al., 2006; Raine et al., 1998; Timmermans, van Lier, & Koot, 2008). Moore et al. (2014) hypothesise that physical aggression can serve as a respite and escape from stressful situations, and Raine et al. (1998) purports that it may be a way for young people to seek attention from their caregivers and peers, or to obtain rewards and social status.

**Rationale for this Quantitative Review**

Given the negative implications for the long-term developmental trajectory of children and adolescents who are overweight/obese or whom engage in physically aggressive behaviour, further investigation of this relationship appears warranted. Whilst many studies reported data for the required variables (i.e., BMI and incidences of physical aggression), many examined other associations rather than a direct relationship between overweight/obesity and physical aggression. Since significance testing is highly dependent on sample size, it is important to identify effects across pooled samples in order to synthesise findings from prior studies. Neither a systematic review nor a meta-analysis of the existing literature relevant to the relationship between overweight/obesity and physical aggression in children and adolescents has been previously published. The present paper aimed to complete a systematic review and a meta-analysis of the association between overweight/obesity and physical aggression in children and adolescents.
Method

The literature review and meta-analysis was undertaken in accordance with the recommended PRISMA guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009).

Inclusion and Exclusion Criteria

The definition of physical aggression included actions deliberately targeted at physically injuring other individuals. In order to widen the search for relevant articles, search terms with similar meanings (such as aggression, bullying, externalising behaviour, physical assault, and criminal offending) or conditions that include physically aggressive behaviour in their symptomatology (such as Conduct Disorder (CD)) were also included.

The independent predictor involved measurements of overweight/obesity only (indicated by measures of Body Mass Index (BMI) and bulk index), and did not include variants of measurements of body size such as body shape or muscle mass.

Participants up to the age of eighteen years were included in the analyses, and studies of a cross-sectional and longitudinal nature were included.

Literature Search

An initial search for articles relevant to the review was conducted utilising the following electronic databases: PsycInfo; Medline Complete; Web of Knowledge; Academic Search Complete; and SCOPUS. A comprehensive list of the search terms are listed in Table 1.

PsycINFO was also searched for unpublished dissertations using the same search terms and limiters. The abstracts of all dissertations registered since 1995 (the point at which full abstracts are available) featuring the search terms and limiters were checked for relevance to the meta-analysis. The pre-specified search criteria were adapted as
necessary for each database, and articles published at any time from the beginning of the database records until the search cut-off date (August 2013) were included. This search produced an initial list of 2,437 articles. Once duplicates were removed, the number of articles for screening was 1,522. The volume of articles suggested by the searches reflected the sensitivity of the search terms used. In deciding which key words and phrases to specify in the search, sensitivity took precedence over specificity; thus, a number of broader terms were used in order to reduce the risk of missing any relevant studies. As a result, a large number of the articles that initially appeared relevant for inclusion were excluded at the title stage. For example, studies concentrating solely on perpetrators of verbal aggression or relational bullying (as opposed to those concerning physical aggression) were excluded at this stage. Manual searches were also made from reference lists of all included articles for potentially eligible studies to include in this review, which yielded an additional 11 articles. Once records deemed to be irrelevant were excluded, 33 articles remained to be assessed for eligibility.
Table 1. Summary of databases, search terms, limiters, number of results from each database, and the dates between which the research spanned.

<table>
<thead>
<tr>
<th>Database</th>
<th>Search terms</th>
<th>Years between which the research spanned</th>
<th>Limiters</th>
<th>Total number of results</th>
</tr>
</thead>
<tbody>
<tr>
<td>PsycInfo</td>
<td>(&quot;body size&quot; OR &quot;obes*&quot; OR &quot;overweight&quot; OR &quot;BMI&quot; OR &quot;body mass index&quot;) AND (&quot;aggressi*&quot; OR &quot;antisocial behavi*&quot; OR &quot;conduct disorder&quot; OR &quot;oppositional defiant disorder&quot; OR &quot;bull*&quot; OR &quot;externali?ing behavi*&quot; OR &quot;physical assault&quot;) AND (&quot;child*&quot; OR &quot;adolescen*&quot;)</td>
<td>1936-2013</td>
<td>English; Age Groups: Childhood (birth-12 yrs), Adolescence (13-17 yrs); Population Group: Human; Methodology: CLINICAL CASE STUDY, EMPIRICAL STUDY, -Experimental Replication, -Followup Study, -Longitudinal Study, ---Prospective Study, ---Retrospective Study, FIELD STUDY, LITERATURE REVIEW, -Systematic Review, MATHEMATICAL MODEL, -Meta Analysis, -Nonclinical Case Study, -Qualitative Study, -Quantitative Study, TREATMENT OUTCOME/CLINICAL TRIAL, TWIN STUDY</td>
<td>180</td>
</tr>
<tr>
<td>Medline Complete</td>
<td>As above</td>
<td>1963-2013</td>
<td>Human; Age Related: All Child: 0-18 years; Language: English Article, Other, Case Report, Clinical Trial, Reference Material. Language: English</td>
<td>499</td>
</tr>
<tr>
<td>Web of Knowledge</td>
<td>As above</td>
<td>1943-2013</td>
<td></td>
<td>795</td>
</tr>
<tr>
<td>Academic Search</td>
<td>As above</td>
<td>1987-2013</td>
<td>Document Type: Article, Book Chapter, Case Study, Interview; Language: English</td>
<td>374</td>
</tr>
<tr>
<td>Complete</td>
<td>As above</td>
<td>1954-2013</td>
<td></td>
<td>589</td>
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</table>
The abstracts of these remaining 33 articles were then read in full and 23 studies were included. A summary of the selection process used in this meta-analysis are outlined in the PRISMA flowchart (Figure 2).

Figure 2. PRISMA flowchart showing selection of articles included in the meta-analysis
Hard copies of these studies were retrieved, and seven of the retrieved articles were excluded after initial reading as they did not meet the inclusion criteria. Two studies with relevant data (Anderson, Cohen, Naumova, & Must, 2006) were excluded because of inadequate sample and statistical information, and attempts to contact these authors for clarification were unsuccessful. Another study with relevant data (BeLue, Francis, & Colaco, 2009) was excluded because the statistical data was unclear. The narrative synthesis and data extraction was undertaken by the lead author. This method produced a final list of 23 articles that fell within the scope of the review. Characteristics of the studies included are detailed in Table 2.
<table>
<thead>
<tr>
<th>Study Reference (including Country, Sample Size, and Sample Characteristics)</th>
<th>Controlled Variables</th>
<th>Outcome Variables</th>
<th>Relevant Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Banis et al. (1988) (USA, N = 30, 7-12 years)*</td>
<td>Gender, age, Body Mass Index (BMI), ethnicity, socioeconomic status (SES)</td>
<td>Aggressive behaviour (assessed by structured diagnostic interview and the Diagnostic Interview Schedule for Children (DISC))</td>
<td>Obese girls were significantly different in levels of aggression from normal weight girls that were clinic-referred (p &lt; .001) or non-clinic-referred (p &lt; .001). Obese girls were significantly different in levels of cruelty to others from normal weight girls that were clinic-referred (p &lt; .001) or non-clinic-referred (p &lt; .05). Obese boys were significantly different in levels of aggression from normal weight boys that were clinic-referred (p &lt; .001) or non-clinic-referred (p &lt; .001)</td>
</tr>
<tr>
<td>Baum and Forehand (1984) (USA, N = 48, grades 6-7)*</td>
<td>Gender, age, ethnicity, body size (thin/underweight, average, chubby/slightly overweight, fat/moderately to extremely overweight)</td>
<td>Behavioural observations of dispensing negative behaviours (including physical attacks and threats on others) by undergraduate psychology students</td>
<td>Both the chubby build and fat build groups received and dispensed a significantly greater percentage of negative interactions than the average weight group (p &lt; .05)</td>
</tr>
<tr>
<td>Study</td>
<td>Country, N, Age</td>
<td>Variables</td>
<td>Outcome</td>
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<tr>
<td>Berg et al. (2005)</td>
<td>Sweden, N = 959 boys, 15 years*</td>
<td>BMI, social factors, eating habits and physical activity, body image and relations, school situation, use of alcohol/drugs/tobacco, somatic/psychological symptoms</td>
<td>Physical aggression (kicking or hitting)</td>
</tr>
<tr>
<td>Datar and Sturm (2004)</td>
<td>USA, N = 9,949, grades 1-2**/***</td>
<td>Gender, BMI, ethnicity, mother’s education level, annual family income, family structure, parent-child interaction, birth weight, and maternal depressive symptoms</td>
<td>Externalising behaviour (including fighting and disturbing ongoing activities)</td>
</tr>
<tr>
<td>Eschenbeck et al. (2009)</td>
<td>Germany, N = 156,948, 6-14 years*</td>
<td>Gender, age</td>
<td>Externalising disorder (including conduct disorders)</td>
</tr>
<tr>
<td>Farhat et al. (2010)</td>
<td>USA, N = 7,825, 11-17 years*</td>
<td>Age, BMI, ethnicity, family composition, family affluence</td>
<td>Physical fighting</td>
</tr>
<tr>
<td>Gallup and Wilson (2009)</td>
<td>USA, N = 155, 13-16 years*</td>
<td>Gender, BMI, ethnicity</td>
<td>Physical aggression (hitting, kicking, physical intimidation)</td>
</tr>
<tr>
<td>Griffiths et al. (2006)</td>
<td>United Kingdom, N = 8,210, 7.5-8.5 years**</td>
<td>Age, gender, BMI, parental social class (manual vs non-manual occupations)</td>
<td>Overt bullying (including threatening/blackmailing, hitting, or beating up)</td>
</tr>
<tr>
<td>Halfon et al. (2013)</td>
<td>USA, N = 43,296, 10-17 years*</td>
<td>Age, BMI, ethnicity, household income, family structure, parental education level</td>
<td>Externalising problems (bullying or being cruel, assessed by the Behaviour Problems Index (BPI))</td>
</tr>
<tr>
<td>Study (Year)</td>
<td>Country, Sample Size</td>
<td>Predictors</td>
<td>Outcomes</td>
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<tr>
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<tr>
<td>Hwang et al. (2006) (South Korea, N = 453, grades 4-6)</td>
<td>Gender, BMI</td>
<td>Aggressive behaviour (assessed by the Aggressive Behaviour Subscale of the Child Behaviour Checklist (CBCL))</td>
<td>Overweight children obtained significantly higher scores on the subscale measuring aggressive behaviour compared to children who were ‘at risk of overweight’ (p = .025)</td>
</tr>
<tr>
<td>Ikaheimo et al. (2007) (Finland, N = 5,589 boys, measured at birth, 12 months, 14 years, up to 32 years)**</td>
<td>Age, BMI, maternal age, SES at birth, mother’s parity, marital status, smoking status, wantedness of the pregnancy, gestational age of the child</td>
<td>Violent offending (homicide, attempted homicide, assault, robbery, arson, sexual crimes, violation of domestic peace)</td>
<td>Infants with high BMI at 12 months of age were significantly more likely to engage in violent offending behaviour in adulthood (p = .001)</td>
</tr>
<tr>
<td>Janssen et al. (2004) (Canada, N = 5,479, 11-16 years)*</td>
<td>Age, gender, BMI</td>
<td>Physical bullying (hitting, shoving, kicking, pushing)</td>
<td>Physical bullying increased with increasing BMI category in girls (p &lt; .05)</td>
</tr>
<tr>
<td>Lumeng et al. (2003) (USA, N = 755, 8-11 years)*</td>
<td>Gender, ethnicity, mother’s marital status, mother’s education level, family poverty status, mother’s obesity, mother’s depressive symptoms, mother’s smoking status, use of behaviour-modifying medication, hours of television per day, and history of academic grade retention</td>
<td>Aggression scores (assessed by the BPI)</td>
<td>Significant relationship between being overweight and clinically meaningful behaviour (scores above the 90th percentile on the BPI) (p = .01)</td>
</tr>
<tr>
<td>Luukkonen et al. (2011) (Finland, N = 508, 12-17 years)*</td>
<td>Gender, family type, repeated grade at school</td>
<td>Bullying (assessed by scores on the semi-structured Schedule for Affective Disorder and</td>
<td>No significant relationship between overweight status and being a bully or bully-victim</td>
</tr>
<tr>
<td>Study</td>
<td>Sample Description</td>
<td>Risk Factors &amp; Environmental Influences</td>
<td>Mental Health Outcomes</td>
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<tr>
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<tr>
<td>Mustillo et al. (2003) (USA, N = 991, 9-13 years then annual follow-up until 16)**</td>
<td>Age, gender, BMI, family income, parental education, family structure, parental mental illness history, drug abuse or criminal convictions, harsh/overprotective parenting style, lax supervision, traumatic life events</td>
<td>Oppositional Defiant Disorder or Conduct Disorder diagnoses (assessed by the Child and Adolescent Psychiatric Assessment)</td>
<td>Diagnoses of Oppositional Defiant Disorder was significantly more common in chronically obese boys and girls (p &lt; .01)</td>
</tr>
<tr>
<td>Pasch et al. (2008) (USA, N = 3,010, grades 7-8)**</td>
<td>Age, BMI, SES, family structure, ethnicity</td>
<td>Physical fighting behaviour</td>
<td>No significant relationship between BMI in grade 7 and fighting behaviour in grade 7 or grade 8</td>
</tr>
<tr>
<td>Piko et al. (2006) (Hungary, N = 550, 10-15 years)*</td>
<td>Age*, BMI, gender, school achievement (grades from school)</td>
<td>Physical aggression (measured by the Aggression Questionnaire)</td>
<td>Significant relationship between BMI and physical aggression in boys (p &lt; .05)</td>
</tr>
<tr>
<td>Study</td>
<td>Sample Details</td>
<td>Variables</td>
<td>Outcomes</td>
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<tr>
<td>Pitrou et al. (2010)</td>
<td>(France, N = 2,341, 6-11 years)*</td>
<td>Age*, gender, BMI, lifestyle behaviours (physical activity outside school, watching TV, playing video games, participation in organised sports), sociodemographic characteristics (parental education, parents’ employment status, household income, family structure), parental psychological distress and alcohol misuse, traumatic life events, parenting style (caring/punitive behaviours, autonomy-promoting, overprotective attitudes), academic achievement</td>
<td>No significant relationship between BMI and possible ODD or CD diagnoses or parent-reported conduct disorders</td>
</tr>
<tr>
<td>Raine et al. (1998)</td>
<td>(Mauritius, N = 1,795, 3 and 11 years)*/**</td>
<td>Gender, ethnicity, bulk index (measured using height and weight), SES</td>
<td>Aggressive children at age 3 were significantly taller (p &lt; .002), heavier (p &lt; .02) and bulkier (p &lt; .004) relative to non-aggressive children. Body size at age 3 years was related to aggression at age 11 (height p &lt; .007, bulk p &lt; .04, weight p &lt; .09)</td>
</tr>
</tbody>
</table>
Sawyer et al. (2006) (Australian N = 4,983, 4-5 years)**
Gender, BMI, ethnicity, indigenous status, maternal sociodemographics (highest education level, psychological distress), family sociodemographics (occupation, income), neighbourhood sociodemographics (neighbourhood disadvantage)
Self-, parent-, and teacher-reported conduct problems (measured by the SDQ)
Significant relationship between teacher-reported conduct problems and BMI in boys (p < .05)

Seyedamini et al. (2012) (Iran, N = 300 girls, 7-12 years)*
BMI, sociodemographics (maternal education level, birth order, TV watching duration), crisis experience during last six months, previous disease history, birth weight
Aggressive behaviour (assessed by the CBCL)
Significant relationship between aggression in overweight (p = .0001) and obese (p = .03) girls.

Tremblay et al. (1998) (Canada, N = 1,037 boys, 6-13 years)**
Age, parents’ age (at child’s birth), parents’ educational/occupational status, family composition (at age 6), BMI, testosterone levels
Physical aggression (assessed using the Social Behaviour Questionnaire for teacher-reports, the Pupil Evaluation Inventory for peer-ratings, and a 27-item self-report delinquency questionnaire)
BMI significantly correlated with self-reported physical aggression (p < .001). Self-reported physical aggression at age 13 was correlated with BMI at age 12 and 13 (p < .001)
| Zeller et al. (2008) (USA, N = 166, 8-16 years)* | Age*, BMI, ethnicity, SES, family composition, family size, parental age/education | Aggressive-disruptive behaviour (including engaging in physical fighting) rated by peers, teachers, and self | BMI significantly correlated with peer-reported aggressive-disruptive behaviour (p = .03) |

* Cross-sectional design  
** Longitudinal design  
+ Separate sub-analyses for age differences was not reported
Nineteen of the articles identified for inclusion in this meta-analysis measured some form of physically aggressive behaviour. The types of behaviours included the following:

- Aggressive and cruel behaviours (as measured by the Aggression subscale of the Child Behavior Checklist) (Halfon et al., 2013; Hwang et al., 2006; Ikaheimo et al., 2007; Lumeng et al., 2003; Raine et al., 1998; Seyedamini et al., 2012)
- Physical attacks and fighting (Datar & Sturm, 2004; Farhat et al., 2010; Lumeng et al., 2003; Pasch et al., 2008; Raine et al., 1998; Tremblay et al., 1998)
- Threats (including threats to physically assault another) (Lumeng et al., 2003)
- Kicking, pushing, or hitting (Janssen et al., 2004)
- Bullying (including overt bullying) (Farhat et al., 2010; Griffiths et al., 2006; Halfon et al., 2013; Janssen et al., 2004; Lumeng et al., 2003)
- Conduct problems and disorders (Eschenbeck et al., 2009; Mustillo et al., 2003; Pitrou et al., 2010; Sawyer et al., 2006)
- Violent offending behaviour (Ikaheimo et al., 2007)

Diverse data-recording methodologies were utilised, including:

- Psychometric testing, utilising self-, parent-, and teacher-report measures such as the Child Behavior Checklist (Hwang et al., 2006; Ikaheimo et al., 2007; Raine et al., 1998; Seyedamini et al., 2012), the Bullying and Friendship Schedule (Griffiths et al., 2006), the Behavior Problem Index (Halfon et al., 2013; Lumeng et al., 2003), the Aggression Questionnaire (Piko et al., 2006), the Schedule for Affective Disorder and Schizophrenia for School-Age Children,
Present and Lifetime (Luukkonen et al., 2011) and the Strengths and Difficulties Questionnaire (Pitrou et al., 2010; Sawyer et al., 2006)

• Behavioural observations (Lumeng et al., 2003)
• National surveys (Griffiths et al., 2006; Halfon et al., 2013; Ikaheimo et al., 2007; Janssen et al., 2004; Lumeng et al., 2003; Mustillo et al., 2003; Pitrou et al., 2010; Sawyer et al., 2006)
• Health insurance surveys (Eschenbeck et al., 2009)
• Self-, parent-, teacher-reported questionnaires (Pasch et al., 2008; Piko et al., 2006; Tremblay et al., 1998; Zeller et al., 2008)
• Criminal records (Ikaheimo et al., 2007)

In the majority of studies, overweight/obesity indicators were obtained by calculating the Body Mass Index, a standard formula involving height and weight (Datar & Sturm, 2004; Farhat et al., 2010; Griffiths et al., 2006; Halfon et al., 2013; Hwang et al., 2006; Ikaheimo et al., 2007; Janssen et al., 2004; Lumeng et al., 2003; Mustillo et al., 2003; Pasch et al., 2008; Pitrou et al., 2010; Raine et al., 1998; Sawyer et al., 2006; Seyedamini et al., 2012; Tremblay et al., 1998). Current research suggests that BMI is an accurate and widely-used measure of overweight/obesity (Aeberli, Gut-Knabenhans, Kusche-Ammann, Molinari, & Zimmermann, 2013; Laurson, Eisenmann, & Welk, 2011; Ralston, Walker, & Truby, 2012). In the remaining studies, observer ratings (of thin/underweight, average, chubby/slightly overweight, and fat/moderately to extremely overweight) (Lumeng et al., 2003), physician-diagnosed obesity (Eschenbeck et al., 2009), and a bulk index (calculated as the z-transformation of the product of height and weight, with a constant of 1 added to scores) (Raine et al., 1998) were used.
Of the 23 studies included in this meta-analysis, the results from three studies utilised unadjusted correlations and reported only the ages, genders, and BMIs of the participants (Eschenbeck et al., 2009; Hwang et al., 2006; Janssen et al., 2004), the remaining twenty controlled for factors such as socioeconomic status (including neighbourhood socio-demographics (Banis et al., 1988; Datar & Sturm, 2004; Farhat et al., 2010; Griffiths et al., 2006; Halfon et al., 2013; Ikaheimo et al., 2007; Lumeng et al., 2003; Mustillo et al., 2003; Pasch et al., 2008; Pitrou et al., 2010; Raine et al., 1998; Sawyer et al., 2006; Zeller et al., 2008)), mental illness (Berg et al., 2005; Mustillo et al., 2003; Seyedamini et al., 2012), and problematic alcohol or drug use (Berg et al., 2005).

**Effect Size Calculations and Data Extraction Procedures**

From each study, data was extracted to allow an effect size to be computed along with its variance that quantified the effect of overweight/obesity on physical aggression, using a standardised mean difference (SMD) as the effect size measure. Positive values indicated that children and adolescents who were overweight or obese evidenced higher incidences of engaging in physical aggression as compared to those who were underweight or of normal weight.

Comprehensive Meta-Analysis Software Package (Borenstein, Hedges, Higgins, & Rothstein, 2011) was used to convert the extracted data to a common effect size and variance.

**Meta-Analytic Procedures**

Effect sizes from each study were pooled and a weighted average effect size was computed using a random effects model as the differences between study level effect sizes were assumed to be the sum of sampling error (within-study variance) and ‘true’
effect size differences (between-study variance) and additionally, the sample characteristics of each study and the outcome measures used were not presumed to be equivalent. Significance tests for the weighted average effect size was computed using an alpha level of .05.

The total amount of heterogeneity between studies was measured using the $Q$ and $I^2$ statistics, which described the presence and amount of heterogeneity (respectively) in effect sizes (as a percentage or proportion) that was attributable to between-study effects rather than within-study effects (e.g., participant or methodological characteristics) (Higgins & Thompson, 2002). As a guideline, Higgins, Thompson, Deeks, and Altman (2003) suggest that values of 25%, 50%, and 75% correspond to low, moderate, and high levels of heterogeneity respectively.

**Publication Bias Analyses**

Publication bias can occur due to problems such as non-publication of non-significant findings. To investigate this issue Funnel plots and Egger’s test of asymmetry were conducted to measure whether the average effect sizes were more often identified in the larger (higher precision) studies and whether the distribution was symmetric (Egger, Smith, Schneider, & Minder, 1997). Rosenthal’s Fail-Safe N was computed to assess whether possible non-significant studies were inadvertently omitted from the analysis, which would reduce the observed collective effect size.

**Results**

**Overweight/Obesity and Physical Aggression: Adjusted Effect Sizes**

A total of 23 studies were included. The effect sizes computed for each study and the weighted average effect size are presented as a forest plot in Figure 3. Positive SMD values indicated that overweight or obese children or adolescents were more likely to be
physically aggressive than their average-weight or underweight peers. The weighted average effect size computed was .27 (95% Confidence Interval [CI₀₉]: .17 - .37), and highly significant (p < .001). This indicated that on average, children and adolescents who were overweight or obese were more likely to engage in physical aggression than their peers who were not overweight or obese. According to Cohen (1988) taxonomy, this corresponds to a small to medium effect size.

Table 3 demonstrates that there was substantial variability in study level effect sizes. For example, the largest effect size observed was 1.22 and the smallest -0.30. The effects across studies were highly heterogeneous (Q(46) = 823.15, p < .001). Calculation of the \( I^2 \) statistic confirmed this, and provided further indication that 94.41% of variability between effect sizes represented true heterogeneity, a strong suggestion of the existence of genuine differences underlying the results of the studies, rather than as a result of chance. The high levels of heterogeneity between the studies included in the analysis, suggest that both non-systematic study influences and true effects accounted for the differences in study results, thus supporting the decision to utilise a random effects model.
Table 3. Summary of adjusted effect sizes of overweight/obesity on physical aggression across all studies

<table>
<thead>
<tr>
<th>Study name</th>
<th>Subgroup within study</th>
<th>Outcome</th>
<th>Statistics for each study</th>
<th>Std diff in means and 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Std diff in means</td>
</tr>
<tr>
<td>Janssen et al. (2004)</td>
<td>11-12 years boys</td>
<td>All Bullying Behaviours</td>
<td>0.037, 0.254, 0.328</td>
<td>0.802</td>
</tr>
<tr>
<td>Janssen et al. (2004)</td>
<td>11-12 years girls</td>
<td>All Bullying Behaviours</td>
<td>0.077, 0.248, 0.402</td>
<td>0.642</td>
</tr>
<tr>
<td>Janssen et al. (2004)</td>
<td>13-14 years boys</td>
<td>All Bullying Behaviours</td>
<td>0.197, 0.078, 0.472</td>
<td>0.160</td>
</tr>
<tr>
<td>Janssen et al. (2004)</td>
<td>13-14 years girls</td>
<td>All Bullying Behaviours</td>
<td>0.170, 0.138, 0.475</td>
<td>0.279</td>
</tr>
<tr>
<td>Janssen et al. (2004)</td>
<td>15-16 years boys</td>
<td>All Bullying Behaviours</td>
<td>0.186, 0.130, 0.501</td>
<td>0.249</td>
</tr>
<tr>
<td>Janssen et al. (2004)</td>
<td>15-16 years girls</td>
<td>All Bullying Behaviours</td>
<td>0.174, 0.151, 0.498</td>
<td>0.295</td>
</tr>
<tr>
<td>Farhat et al. (2010)</td>
<td>&lt;15 years boys</td>
<td>Physical fighting</td>
<td>-0.034, -0.208, 0.140</td>
<td>0.701</td>
</tr>
<tr>
<td>Farhat et al. (2010)</td>
<td>&lt;15 years girls</td>
<td>Physical fighting</td>
<td>0.174, -0.060, 0.407</td>
<td>0.145</td>
</tr>
<tr>
<td>Farhat et al. (2010)</td>
<td>15+ years boys</td>
<td>Physical fighting</td>
<td>-0.017, -0.284, 0.230</td>
<td>0.902</td>
</tr>
<tr>
<td>Farhat et al. (2010)</td>
<td>15+ years girls</td>
<td>Physical fighting</td>
<td>0.032, -0.251, 0.315</td>
<td>0.824</td>
</tr>
<tr>
<td>Hallow et al. (2013)</td>
<td>10-17 years</td>
<td>Conduct Disorder</td>
<td>0.189, 0.002, 0.381</td>
<td>0.052</td>
</tr>
<tr>
<td>Seyedamini et al. (2012)</td>
<td>7-11 years</td>
<td>Aggressive behaviour</td>
<td>0.067, 0.028, 0.106</td>
<td>0.001</td>
</tr>
<tr>
<td>Lumeng et al. (2003)</td>
<td>8-11 years</td>
<td>Antisocial behaviour subscale on BPI</td>
<td>0.269, 0.050, 0.489</td>
<td>0.016</td>
</tr>
<tr>
<td>Eschenbeck et al. (2009)</td>
<td>6-14 years boys</td>
<td>Conduct disorders</td>
<td>0.374, 0.282, 0.466</td>
<td>0.000</td>
</tr>
<tr>
<td>Eschenbeck et al. (2009)</td>
<td>6-14 years girls</td>
<td>Conduct disorders</td>
<td>0.529, 0.406, 0.651</td>
<td>0.000</td>
</tr>
<tr>
<td>Pitrou et al. (2010)</td>
<td>6-11 years</td>
<td>CD - likely present</td>
<td>-0.213, -0.746, 0.321</td>
<td>0.435</td>
</tr>
<tr>
<td>Griffiths et al. (2006)</td>
<td>7 years boys</td>
<td>Bullying</td>
<td>0.231, 0.029, 0.470</td>
<td>0.059</td>
</tr>
<tr>
<td>Griffiths et al. (2006)</td>
<td>7 years girls</td>
<td>Bullying</td>
<td>-0.181, -0.652, 0.290</td>
<td>0.451</td>
</tr>
<tr>
<td>Mustillo et al. (2003)</td>
<td>9-16 years</td>
<td>CD</td>
<td>0.019, -0.105, 0.144</td>
<td>0.760</td>
</tr>
<tr>
<td>Ikaheimo et al. (2007)</td>
<td>Birth, 12 months, 14 years, adult boys</td>
<td>Violent offending</td>
<td>0.324, 0.137, 0.511</td>
<td>0.001</td>
</tr>
<tr>
<td>Tremblay et al. (1998)</td>
<td>10 years of age boys</td>
<td>Self rated aggression</td>
<td>0.629, 0.501, 0.757</td>
<td>0.000</td>
</tr>
<tr>
<td>Tremblay et al. (1998)</td>
<td>11 years of age boys</td>
<td>Self rated aggression</td>
<td>0.953, 0.818, 1.088</td>
<td>0.000</td>
</tr>
<tr>
<td>Tremblay et al. (1998)</td>
<td>12 years of age boys</td>
<td>Self rated aggression</td>
<td>1.218, 1.075, 1.360</td>
<td>0.000</td>
</tr>
<tr>
<td>Tremblay et al. (1998)</td>
<td>13 years of age boys</td>
<td>Physical aggression</td>
<td>1.065, 0.927, 1.203</td>
<td>0.000</td>
</tr>
<tr>
<td>Tremblay et al. (1998)</td>
<td>6 years of age boys</td>
<td>Teacher rated aggression</td>
<td>0.242, 0.119, 0.365</td>
<td>0.000</td>
</tr>
<tr>
<td>Datar &amp; Sturm (2004)</td>
<td>First grade boys</td>
<td>Teacher reported externalising problem</td>
<td>0.011, -0.224, 0.246</td>
<td>0.927</td>
</tr>
<tr>
<td>Datar &amp; Sturm (2004)</td>
<td>First grade girls</td>
<td>Teacher reported externalising problem</td>
<td>0.300, -0.761, 0.160</td>
<td>0.201</td>
</tr>
<tr>
<td>Datar &amp; Sturm (2004)</td>
<td>Kindergarten boys</td>
<td>Teacher reported externalising problem</td>
<td>0.064, -0.253, 0.125</td>
<td>0.505</td>
</tr>
<tr>
<td>Datar &amp; Sturm (2004)</td>
<td>Kindergarten girls</td>
<td>Teacher reported externalising problem</td>
<td>0.327, 0.112, 0.542</td>
<td>0.003</td>
</tr>
<tr>
<td>Pasch et al. (2008)</td>
<td>Grade 7</td>
<td>Fighting behaviour</td>
<td>0.244, 0.003, 0.484</td>
<td>0.047</td>
</tr>
<tr>
<td>Pasch et al. (2008)</td>
<td>Grade 8</td>
<td>Fighting behaviour</td>
<td>0.358, 0.111, 0.604</td>
<td>0.004</td>
</tr>
<tr>
<td>Sawyer et al. (2009)</td>
<td>4-5 years of age boys</td>
<td>Parent-reported conduct problems</td>
<td>0.588, 0.499, 0.677</td>
<td>0.000</td>
</tr>
<tr>
<td>Sawyer et al. (2009)</td>
<td>4-5 years of age girls</td>
<td>Teacher-reported conduct problems</td>
<td>0.746, 0.656, 0.836</td>
<td>0.000</td>
</tr>
<tr>
<td>Zeiler et al. (2008)</td>
<td>6-16 years</td>
<td>Combined</td>
<td>0.190, -0.118, 0.497</td>
<td>0.226</td>
</tr>
<tr>
<td>Luukkonen et al. (2010)</td>
<td>12-17 years boys</td>
<td>Bull or bully-victim</td>
<td>-0.109, -0.917, 0.998</td>
<td>0.791</td>
</tr>
<tr>
<td>Luukkonen et al. (2010)</td>
<td>12-17 years girls</td>
<td>Bull or bully-victim</td>
<td>0.165, -0.545, 0.876</td>
<td>0.648</td>
</tr>
<tr>
<td>Berg et al. (2005)</td>
<td>15 years boys</td>
<td>Ever kicked or hit</td>
<td>0.296, -0.053, 0.505</td>
<td>0.102</td>
</tr>
<tr>
<td>Gallup &amp; Wilson (2009)</td>
<td>13-15 years boys</td>
<td>Peer aggression</td>
<td>0.125, -0.193, 0.444</td>
<td>0.404</td>
</tr>
<tr>
<td>Gallup &amp; Wilson (2009)</td>
<td>13-15 years girls</td>
<td>Peer aggression</td>
<td>0.380, 0.056, 0.704</td>
<td>0.021</td>
</tr>
<tr>
<td>Piko et al. (2005)</td>
<td>10-15 years boys</td>
<td>Physical aggression</td>
<td>0.283, 0.053, 0.512</td>
<td>0.016</td>
</tr>
<tr>
<td>Piko et al. (2005)</td>
<td>10-15 years girls</td>
<td>Physical aggression</td>
<td>0.120, -0.130, 0.371</td>
<td>0.347</td>
</tr>
<tr>
<td>Baum &amp; Forehand (1984)</td>
<td>Grade 6-7</td>
<td>Disrupting negative peer interactions</td>
<td>0.594, -0.016, 1.303</td>
<td>0.056</td>
</tr>
<tr>
<td>Banis et al. (1988)</td>
<td>7-12 years boys</td>
<td>Combined</td>
<td>0.438, 0.076, 0.800</td>
<td>0.018</td>
</tr>
<tr>
<td>Banis et al. (1988)</td>
<td>7-12 years girls</td>
<td>Aggressiveness</td>
<td>0.572, 0.209, 0.934</td>
<td>0.002</td>
</tr>
<tr>
<td>Hwang et al. (2008)</td>
<td>Grade 4-6</td>
<td>Aggressive behaviour</td>
<td>0.185, -0.000, 0.371</td>
<td>0.051</td>
</tr>
<tr>
<td>Raine et al. (1998)</td>
<td>11 years</td>
<td>Aggressive behaviour</td>
<td>0.019, -0.073, 0.112</td>
<td>0.680</td>
</tr>
<tr>
<td>Raine et al. (1998)</td>
<td>3 years</td>
<td>Aggressive behaviour</td>
<td>0.125, 0.033, 0.218</td>
<td>0.098</td>
</tr>
</tbody>
</table>

-0.100 -0.050 0.00 0.050 0.100

-1.00 -0.50 0.00 0.50 1.00
Two sub-analyses controlling for gender were conducted in order to ascertain whether the overall significant effect between overweight/obesity and physical aggression was maintained. Of the 23 studies included in this meta-analysis, 13 studies were included in a sub-analysis investigating the relationship between overweight/obesity and physical aggression in boys, and 10 studies in a sub-analysis investigating the relationship between overweight/obesity and physical aggression in girls. The results demonstrated that overweight/obesity status of both genders were significantly associated with physically aggressive behaviour. Compared to their normal-weight peers, overweight or obese boys were more likely to be physically aggressive (SMD = .35, CI95: .18 - .52, p < .001) with this effect also significant but somewhat smaller for overweight or obese girls (SMD = .24, CI95: .07 - .42, p < .01). The results of these analyses are presented as forest plots in Tables 4 and 5.
Table 4. Summary of adjusted effect sizes of overweight/obesity on physical aggression for boys

<table>
<thead>
<tr>
<th>Study name</th>
<th>Subgroup within study</th>
<th>Outcome</th>
<th>Std diff in means</th>
<th>Statistics for each study</th>
<th>Std diff in means and 95% CI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lower limit</td>
<td>Upper limit</td>
<td></td>
</tr>
<tr>
<td>Janssen et al. (2004)</td>
<td>11-12 years boys</td>
<td>All Bullying Behaviours</td>
<td>0.037</td>
<td>-0.254</td>
<td>0.328</td>
</tr>
<tr>
<td>Janssen et al. (2004)</td>
<td>13-14 years boys</td>
<td>All Bullying Behaviours</td>
<td>0.197</td>
<td>-0.078</td>
<td>0.472</td>
</tr>
<tr>
<td>Janssen et al. (2004)</td>
<td>15-16 years boys</td>
<td>All Bullying Behaviours</td>
<td>0.186</td>
<td>-0.130</td>
<td>0.501</td>
</tr>
<tr>
<td>Farhat et al. (2010)</td>
<td>&lt;15 years boys</td>
<td>Physical fighting</td>
<td>-0.034</td>
<td>-0.208</td>
<td>0.140</td>
</tr>
<tr>
<td>Farhat et al. (2010)</td>
<td>15+ years boys</td>
<td>Physical fighting</td>
<td>-0.017</td>
<td>-0.284</td>
<td>0.250</td>
</tr>
<tr>
<td>Eschenbeck et al. (2009)</td>
<td>6-14 years boys</td>
<td>Conduct disorders</td>
<td>0.374</td>
<td>0.282</td>
<td>0.466</td>
</tr>
<tr>
<td>Griffiths et al. (2006)</td>
<td>7 years boys</td>
<td>Bullying</td>
<td>0.231</td>
<td>-0.009</td>
<td>0.470</td>
</tr>
<tr>
<td>Ikaheimo et al. (2007)</td>
<td>Birth, 12 months, 14 years, adult boys</td>
<td>Violent offending</td>
<td>0.324</td>
<td>0.137</td>
<td>0.511</td>
</tr>
<tr>
<td>Tremblay et al. (1998)</td>
<td>10 years of age boys</td>
<td>Self rated aggression</td>
<td>0.629</td>
<td>0.501</td>
<td>0.757</td>
</tr>
<tr>
<td>Tremblay et al. (1998)</td>
<td>11 years of age boys</td>
<td>Self rated aggression</td>
<td>0.953</td>
<td>0.818</td>
<td>1.088</td>
</tr>
<tr>
<td>Tremblay et al. (1998)</td>
<td>12 years of age boys</td>
<td>Self rated aggression</td>
<td>1.218</td>
<td>1.075</td>
<td>1.360</td>
</tr>
<tr>
<td>Tremblay et al. (1998)</td>
<td>13 years of age boys</td>
<td>Physical aggression</td>
<td>1.065</td>
<td>0.927</td>
<td>1.203</td>
</tr>
<tr>
<td>Tremblay et al. (1998)</td>
<td>6 years of age boys</td>
<td>Teacher rated aggression</td>
<td>0.242</td>
<td>0.119</td>
<td>0.365</td>
</tr>
<tr>
<td>Datar &amp; Sturm (2004)</td>
<td>First grade boys</td>
<td>Teacher reported externalising problems0.011</td>
<td>-0.224</td>
<td>0.246</td>
<td>0.927</td>
</tr>
<tr>
<td>Datar &amp; Sturm (2004)</td>
<td>Kindergarten boys</td>
<td>Teacher reported externalising problems0.064</td>
<td>-0.253</td>
<td>0.125</td>
<td>0.505</td>
</tr>
<tr>
<td>Sawyer et al. (2006)</td>
<td>4-5 years of age boys</td>
<td>Parent-reported conduct problems</td>
<td>0.588</td>
<td>0.499</td>
<td>0.677</td>
</tr>
<tr>
<td>Luukkonen et al. (2010)</td>
<td>12-17 years boys</td>
<td>Bully or bully-victim</td>
<td>-0.109</td>
<td>-0.917</td>
<td>0.698</td>
</tr>
<tr>
<td>Berg et al. (2005)</td>
<td>15 years boys</td>
<td>Ever kicked or hit</td>
<td>0.266</td>
<td>-0.053</td>
<td>0.584</td>
</tr>
<tr>
<td>Gallup &amp; Wilson (2009)</td>
<td>13-15 years boys</td>
<td>Peer aggression</td>
<td>0.125</td>
<td>-0.193</td>
<td>0.444</td>
</tr>
<tr>
<td>Piko et al. (2005)</td>
<td>10-15 years boys</td>
<td>Physical aggression</td>
<td>0.283</td>
<td>0.053</td>
<td>0.512</td>
</tr>
<tr>
<td>Banis et al. (1988)</td>
<td>7-12 years boys</td>
<td>Combined</td>
<td>0.438</td>
<td>0.076</td>
<td>0.800</td>
</tr>
</tbody>
</table>

-1.00 -0.50 0.00 0.50 1.00
Table 5. Summary of adjusted effect sizes of overweight/obesity on physical aggression for girls

<table>
<thead>
<tr>
<th>Study name</th>
<th>Subgroup within study</th>
<th>Outcome</th>
<th>Std diff in means</th>
<th>Lower limit</th>
<th>Upper limit</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Janssen et al. (2004)</td>
<td>11-12 years girls</td>
<td>All Bullying Behaviours</td>
<td>0.077</td>
<td>-0.248</td>
<td>0.402</td>
<td>0.642</td>
</tr>
<tr>
<td>Janssen et al. (2004)</td>
<td>13-14 years girls</td>
<td>All Bullying Behaviours</td>
<td>0.170</td>
<td>-0.136</td>
<td>0.475</td>
<td>0.276</td>
</tr>
<tr>
<td>Janssen et al. (2004)</td>
<td>15-16 years girls</td>
<td>All Bullying Behaviours</td>
<td>0.174</td>
<td>-0.151</td>
<td>0.498</td>
<td>0.295</td>
</tr>
<tr>
<td>Farhat et al. (2010)</td>
<td>&lt;15 years girls</td>
<td>Physical fighting</td>
<td>0.174</td>
<td>-0.060</td>
<td>0.407</td>
<td>0.145</td>
</tr>
<tr>
<td>Farhat et al. (2010)</td>
<td>15+ years girls</td>
<td>Physical fighting</td>
<td>0.032</td>
<td>-0.251</td>
<td>0.315</td>
<td>0.824</td>
</tr>
<tr>
<td>Eschenbeck et al. (2009)</td>
<td>6-14 years girls</td>
<td>Conduct disorders</td>
<td>0.529</td>
<td>0.406</td>
<td>0.651</td>
<td>0.000</td>
</tr>
<tr>
<td>Griffiths et al. (2006)</td>
<td>7 years girls</td>
<td>Bullying</td>
<td>-0.181</td>
<td>-0.652</td>
<td>0.290</td>
<td>0.451</td>
</tr>
<tr>
<td>Datar &amp; Sturm (2004)</td>
<td>First grade girls</td>
<td>Teacher reported externalising problems</td>
<td>-0.300</td>
<td>-0.761</td>
<td>0.160</td>
<td>0.201</td>
</tr>
<tr>
<td>Datar &amp; Sturm (2004)</td>
<td>Kindergarten girls</td>
<td>Teacher reported externalising problems</td>
<td>0.327</td>
<td>0.112</td>
<td>0.542</td>
<td>0.003</td>
</tr>
<tr>
<td>Sawyer et al. (2006)</td>
<td>4-5 years of age girls</td>
<td>Teacher-reported conduct problems</td>
<td>0.746</td>
<td>0.656</td>
<td>0.836</td>
<td>0.000</td>
</tr>
<tr>
<td>Luukkanen et al. (2010)</td>
<td>12-17 years girls</td>
<td>Bully or bully-victim</td>
<td>0.165</td>
<td>-0.545</td>
<td>0.876</td>
<td>0.648</td>
</tr>
<tr>
<td>Gallup &amp; Wilson (2009)</td>
<td>13-15 years girls</td>
<td>Peer aggression</td>
<td>0.380</td>
<td>0.056</td>
<td>0.704</td>
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<td>Piko et al. (2005)</td>
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<td>Aggressiveness</td>
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Sub-analyses for age groups were unable to be conducted, as the age group clusters were varied, and when all the available data was collated, many of the age groups overlapped without a way of discerning the distribution of participants at each age.

**Publication Bias Analyses**

Evidence of publication bias was not found. The funnel plot appeared visually symmetrical, and this was supported by Egger’s test of asymmetry, which was not significant (intercept = 0.53, t(45) = 0.50, p = .31 (one-tailed)). Additionally, Rosenthal’s Fail-Safe N yielded a value of 5,888 suggesting that an additional 5,888 studies not yielding significant correlations between overweight/obesity and physical aggression in children and adolescents would be needed to increase the p-value for the meta-analysis to above 0.05 and nullify the current significant results.

**Discussion**

The aim of this paper was to systematically review prior studies in order to complete a meta-analysis to ascertain the strength of the relationship between overweight/obesity and physical aggression in children and adolescents. Pooling the data from 23 international studies, it was identified that physical aggression was significantly associated with overweight and obesity. Overweight and obese children and adolescents were more likely to engage in physically aggressive behaviours, compared to those who were not obese or overweight. These effects were found to apply across gender, although effects were slightly larger for boys compared to girls. Tests of heterogeneity demonstrated that the collection of studies compiled and included in this analysis were highly dissimilar (94% heterogeneity), suggesting that there may be underlying differences in study characteristics that contribute to the observed association between child and adolescent weight status and aggression.

Despite the wide variations between (and within) the studies included in this analysis (such as differences in participant populations, outcome measures, and study designs), the
meta-analysis supported the view that there is an underlying relationship between overweight/obesity and physical aggression in children and adolescents. The current analysis included studies spanning a wide age group, varying forms of physical aggression, utilisation of different study designs and outcome measures, as well as diverse data collection and reporting methodologies. Many of the included studies were controlled, with well-defined variables, which may have also contributed towards high levels of overall heterogeneity. The number and range of research presented in this review utilised a large number of participants (Total N = 255,377) covered a wide range of ages (from 4 to 17 years of age), geographical locations (including participants from Caucasian, Asian, Middle Eastern, European, Pacific Islander and Scandanavian descent), and measures (such as psychometric tests, behavioural observations, surveys and questionnaires, criminal history records, and self-reports).

It was also unlikely that bias impacted the study selection process used in this analysis. As demonstrated in Figure 3, although the width of the confidence intervals from the studies varied greatly, the combined effect size yielded from the analysis remained highly significant, strengthening the proposition that overweight/obesity could be a risk factor that uniquely contributes to physical aggression in children and adolescents.

Implications for Theory

The findings of this analysis reveal that a small to moderate association exists between overweight/obesity and physical aggression in children and adolescents. These findings raise the importance of investigating the theoretical mechanisms that may explain these associations.

It is possible that having an overweight or large body size could lead to future displays of physical aggression, or that a young person who engages in physically aggressive behaviour may subsequently become overweight or obese. Longitudinal observations can identify temporal order. In the current analysis, data from six longitudinal studies were included and
revealed overall support for theories (Figure 1) that suggest that overweight or large body size leads to future displays of physical aggression. Five studies demonstrated a significant longitudinal relationship showing overweight/obesity preceded physical aggression (Griffiths et al., 2006; Ikaheimo et al., 2007; Pasch et al., 2008; Raine et al., 1998; Tremblay et al., 1998), while one showed effects in a similar direction that were not significant (Mustillo et al., 2003). Griffiths et al. (2006) found no effect for girls. In two studies predictive effects were found to apply from pre-school. Ikaheimo et al. (2007) found that infants with a high BMI at 12 months of age were significantly more likely to engage in violent offending behaviour in adulthood. Raine et al. (1998) found that bulk index (measured using height and weight) at age three was related to physical aggression at age 11. While Tremblay et al. (1998) found evidence that BMI preceded aggression, there was also evidence of reciprocal associations with physical aggression at ages 10 and 11 a significant predictor of BMI at age 12.

Evidence of reciprocal relationships between both overweight/obesity and physical aggression suggests these variables could have common underlying determinants. As discussed in the Introduction, the research literature suggests that several theoretical processes (Figure 1) may contribute in some way to this relationship (such as SES, mental health issues (such as anxiety and depression), and poor self-regulation indicated by engaging in impulsive and risky behaviours (including substance use). The nature of these influences and their potential role as mediator or moderator variables remains unclear.

Based on the present findings it is unlikely that SES fully explains the common association between overweight/obesity and physical aggression. When SES was adjusted for in eight of the included studies the relationship between overweight/obesity and physical aggression remained significant for boys and girls (Banis et al., 1988; Griffiths et al., 2006; Halfon et al., 2013; Ikaheimo et al., 2007; Lumeng et al., 2003; Mustillo et al., 2003; Raine et
al., 1998) and for girls only (Datar & Sturm, 2004). In four studies effects were non-significant and remained so after adjustment for SES for both boys and girls (Farhat et al., 2010; Pasch et al., 2012; Pitrou et al., 2010), and for boys only (Datar & Sturm, 2004). Only one study found a significant association was no longer significant after adjustment for SES (Sawyer et al., 2006). The results of the present analysis, together with the review of the literature in the Introduction, have provided strong indicators that a relationship between overweight/obesity and physical aggression exists amongst children and adolescents.

**Directions for Future Research**

Since overweight/obesity and physically aggressive behaviour can all have dire consequences with respect to mental health outcomes and developmental trajectories, further research investigating this relationship in longitudinal and controlled overweight/obesity prevention trials should take place in order to create and implement early intervention strategies when early indicators are present. The role of common risk factors for physically aggressive behaviour in children and adolescents should be controlled in future studies including: socioeconomic status; health risk behaviours; poor coping skills; mental health symptoms (such as anxiety and depression); impulsive and risky behaviours, while also examining the effects of sedentary behaviours and poor eating habits (Pasch et al., 2008).

Future research should be conducted utilising large, representative samples with measures and methods standardised to be comparable to those most commonly identified in the current review for more consistent results.

Research into the underlying developmental processes that may explain a potential effect of overweight/obesity on physical aggression (see Figure 1) should be completed together with an examination into any mediators or moderators that may influence the relationship. Future studies should seek to understand the reasons for heterogeneity and factors that may modify the association. Advancing theoretical and empirical understanding would enable the
development of effective and targeted intervention strategies to promote overall healthy lifestyle characteristics during this critical age of development.

Limitations

Although results from this meta-analysis implied higher levels of physical aggression among overweight or obese children or adolescents, it cannot address the issue of causality. For example there were no studies that used an intervention design to reduce levels of overweight or obesity and then demonstrate whether this subsequently reduced levels of physical aggression. The majority of data utilised from the included studies used cross-sectional, correlational research designs. However, the six longitudinal studies generally supported the view that overweight/obese children and adolescents subsequently became physically aggressive. To better establish causation, future longitudinal and intervention studies could examine the reciprocal effects of modifying either overweight/obesity or physical aggression or their common determinants.

More detailed sub-analyses (such as for age groups) or meta-regressions were unable to be conducted due to lack of reported data from the studies. Therefore, the present analysis was unable to include information relating to the contributions of covariates, given the variety of study designs included in this analysis, measures and results did not utilise a consistent, standardised format. As such, the accuracy of the results may have been affected.

The general and widely-used measure of overweight/obesity in the developmental literature is of BMI (Aeberli et al., 2013; Mercado-Crespo & Mbah, 2013). A limitation of using BMI as the sole indicator of overweight/obesity, however, is the fact that only measures of overall height and weight of the individual are taken. Factors that may affect an individual’s weight, yet are not an indicator of adiposity (such as muscle mass) are not considered. Indeed, some studies have demonstrated that BMI may be positively correlated with increased muscle strength (and therefore, mass) (Ervin, Fryar, Wang, Miller, & Ogden;
Gallup, White, & Gallup, 2007; Hasan, Kamal, & Hussein, 2016). As such, measures of waist circumference (Aeberli et al., 2013; Daniels, 2009; Freedman & Sherry, 2009) and skinfold thickness tests (Freedman & Sherry, 2009) conducted in addition to a calculation of BMI would increase the sensitivity and accuracy of measurements of overweight/obesity in future research.

A further limitation of this analysis was the variation in outcome measures. For example, the definition of ‘bullying’ in some of the included studies consisted of both relational and physical aggression (Griffiths et al., 2006; Halfon et al., 2013; Luukkonen et al., 2011; Pitrou et al., 2010), and were not separated in the reported results, making it difficult to define the proportions of participants that engaged in relational and physical aggression. This variation in measures may have contributed to the large heterogeneity in the results.

Finally it remains possible that the current findings are limited by publication bias. Given the high value of Rosenthal’s Fail-Safe N, non-reporting of non-significant associations is considered unlikely to have undermined the overall finding of a significant association.

**Conclusion**

Notwithstanding the limitations identified above, this meta-analysis represents an accurate picture of current research and concludes there is a small significant relationship between overweight/obesity and physical aggression in children and adolescents. Given the many adverse physical, social, and psychological effects upon children and adolescents who are larger or physically aggressive, and the financial burden placed on society, it would be pertinent for further longitudinal and intervention research to be conducted to specify the potential causal models defined in Figure 1. This review has highlighted significant between study heterogeneity suggesting that future research should seek to better understand contextual variation and standardise study methods and measures in order to more accurately
specify the causal effect of overweight/obesity on physical aggression in children and adolescents.
Chapter 4: An Ecological Systems Theory (EST) approach to investigating the association between overweight/obesity and physical aggression in children and adolescents

Previous chapters identified that prior studies consistently found associations between overweight/obesity and physical aggression in children and adolescents. In order to more fully understand the mechanism underlying this association, the Ecological Systems Theory (EST) (Bronfenbrenner, 1979; 1994) is examined in the chapter that follows. This chapter seeks to identify key features of the social environment that may influence the association between overweight/obesity and physical aggression in children and adolescents.

Introduction to Bronfenbrenner’s (1979) Ecological Systems Theory of Child Development

Bronfenbrenner’s (Bronfenbrenner, 1979; 1994) Ecological Systems Theory (EST) is an ecological model of child development which posits that individual characteristics (including behaviour) cannot be fully explained without consideration of different aspects of the individual’s environment. In particular, this ‘ecological niche’ surrounding the child includes not only the immediate context in which a person is embedded, but also examines situational contexts, such as that of the community and of the society in which they live more generally (Bronfenbrenner, 1979; 1994). The basis of this model, then, takes into account the broader context that forms part of the child’s world, and considers this in conjunction with characteristics particular to the child, such as gender, age, and personality. This model also considers the child’s interactions with their family, peers, and other adult figures, all of whom may influence their development (Boonpleng et al., 2013).

During late childhood and early adolescence, the school environment serves a pivotal role in a child’s developmental process and asserts itself as one of the most important socialization spaces influencing associations between overweight/obesity and physical
aggression. The school is where relationships are established with peers and other adults (such as teachers) who acquire special significance during this stage (Ferguson, Kasser, & Jahng, 2011). The school environment, in turn, forms part of a neighbourhood, which then also influences the experiences and interactions of everyday relationships the child may have. The school location influences not only relationships with others at school, but with those outside of the school (Schmidt, Pierce, & Stoddard, 2016). A child’s social development is deeply rooted in opportunities, skills, and recognition that accrue through these early interactions with family members, peers, teachers, neighbours, ministers, coaches, and many others (Fraser, 1996). This model highlights the complex reciprocal interactions between an individual and their immediate environment, but also between more distal processes, such as the families’ ability to interact with their environment and utilise resources, which may impact upon the child’s development (Bronfenbrenner, 1979; 1994). EST assumes that social norms and role models for behaviours such as physical activity and eating, that influence overweight/obesity and physical aggression, will be directly influenced by the proximal social environment. EST recognises additionally, that change or instability in one facet of a child’s social environment could potentially affect other levels of the system and in this way influence a child’s development either directly or indirectly (Bronfenbrenner, 1979; 1994). EST seeks to present an accurate picture of the various system forces and influences in a child’s life.

Throughout childhood and adolescence, the family and school are major social and behavioural influences, as these have a direct impact on early childhood opportunities for social participation and the development of a broad range of social and cognitive skills that promote building attachments to other children and adults. If, because of social or economic conditions, children are continually exposed to abusive or stressful events or lack opportunities for and role models of successful social participation, they may be
developmentally disadvantaged in their neuro-physical development (Toumbourou, 2017) and or in developing the necessary skills that will promote success in school, work, and other future life settings (Fraser, 1996). In summary, EST proposes that how a child develops is the result of interactions between the child and the immediate environment. A major influence are factors in the family and school, as well as the characteristics of the community and society in which the child lives (Bronfenbrenner, 1979; 1994). Events within any of these contexts or interactions can have a direct or indirect impact on a child’s risk for maladaptive behaviours, including aggression (Bronfenbrenner, 1979; 1994; Davison & Birch, 2001) and overweight/obesity (Boonpleng et al., 2013; Davison & Birch, 2001; Lin et al., 2014; Zhou & Cheah, 2015).

**Bronfenbrenner (1979) Ecological Systems Theory: Nested Layers of Influence on Child Development.** At the centre of the EST model is the individual, or self-system, which is directly influenced by personal, dispositional, and genetic factors (Boxer et al., 2013). At any point in development, the individual attitudes and behaviours relating to both overweight/obesity and physical aggression will have been shaped by previous experiences, but will also influence future social development. Children and adolescents are not only influenced by factors in their immediate environment, but can be affected by more remotely related nested layers of influence in which they may not participate, such as their parents’ workplaces or support networks (Mason, Cauce, Gonzales, Hiraga, & Grove, 1994). The EST model consists of five layers nested within each other: the microsystem, mesosystem, exosystem, macrosystem, and chronosystem.

**The Microsystem.** The microsystem incorporates all of the direct settings and interactions experienced by the child which may impact on development, including peers, family, community and schools (Barboza et al., 2009; Espelage, 2014). It involves the complex reciprocal interactions between the person aspects of the child and those of the
immediate environment (Bronfenbrenner, 1994), and also includes influences as a result of social roles, activities, and interpersonal relations. Microsystems are believed to influence the behaviour of children and adolescents directly, and also play a mediational role in linking exosystem factors to adolescent behaviour (Bronfenbrenner, 1979). Microsystems are thus considered to play a key role in the development of both overweight/obesity and physical aggression.

**The Mesosystem.** The mesosystem refers to the relationships and inter-relations between the different Microsystems and comprises the linkages and processes taking place between two or more immediate settings in which the child belongs, but may not always include direct contact with the child (Bronfenbrenner, 1994). For example, the mesosystem may include interactions between the child’s family members, peers, and figures at school (such as teachers) (Espelage, 2014). Another example of a mesosystem structure is the influence of family functioning on peer friendship selection or the interaction between family characteristics and individual attributes (Espelage, 2014). Whilst the child may not be directly and actively involved, the result of interactions will still influence the child and their relationships with their peers, teachers, and family members, as well as impact on their perceptions of both their school and home environment, which may in turn, influence the behaviour of each party significantly (Lee, 2010). As one example aggressive interactions witnessed in social or family networks may have a direct influence on the development of child aggression (Espelage, 2014; Fraser, 1996; White & Renk, 2012).

**The Exosystem.** The exosystem comprises the linkages and processes taking place between two or more settings, at least one of which does not contain the child, but in which events occur that indirectly influence processes within the immediate setting of the child, and subsequently will impact on the child’s development indirectly (Zhou & Cheah, 2015). Some examples of factors that lie within a child’s exosystem may be their parents’ economic
situation, such as interactions with the workplace or labour market that result in financial hardship and thereby strain their ability to parent effectively, either as a result of lack of financial resources or because of emotional strain (Conger et al., 2002). As one example, the family access to affordable healthy food and facilities for physical activity may directly and indirectly influence the child’s development.

**The Macrosystem.** The macrosystem includes factors present in the larger culture around the child, such as beliefs, ideologies, and societal attitudes (Espelage, 2014). The macrosystem consists of the overarching pattern of the characteristics of the micro-, meso-, and exosystems of a given culture, with particular reference to the belief system, bodies of knowledge, customs, and life-styles embedded in each of these broader systems (Bronfenbrenner, 1994). This level includes organizational, social, cultural, and political contexts, which influence the interactions within other system levels (e.g., state legislation, discipline policies) (Bronfenbrenner, 1979). As one example, laws and policies associated with the marketing and supply of alcohol, tobacco and unhealthy food influence adolescent development (Toumbourou, Olsson, Rowland, Renati, & Hallam, 2014).

**The Chronosystem.** The final level of the ecological framework, the chronosystem level, includes consistency or change (such as historical or life events) not only in the characteristics of the child, but also of the environment over the child’s life course (Espelage, 2014). These events are of an unpredictable nature, are not preventable, and are minimally influenced by any forces within the other systems, such as changes family structure through divorce, displacement, or death (Bronfenbrenner, 1994).

**The Application of Ecological Systems Theory to the Development of Overweight/Obesity and Aggression in Children and Adolescents**

As discussed in Chapter 1 of this thesis, child and adolescent overweight/obesity rates have increased dramatically over the last 30 years and has become a prevalent issue
worldwide. Globally, it is estimated that 42 million children under the age of five are affected by overweight and obesity (World Health Organization, 2016), and overweight and obese youth are more likely to develop severe obesity and other chronic obesity-related diseases as adults (Christakis & Fowler, 2007; Daniels, 2006).

Past research has concentrated on addressing overweight/obesity on an individual level by focussing on healthy eating, physical activity, and other individual attributes such as impulsivity (Harrist et al., 2013; Lanza et al., 2014), substance use (including alcohol (Battista & Leatherdale, 2017; Fazzino, Fleming, Sher, Sullivan, & Befort, 2017), tobacco (Huang et al., 2013; Lanza et al., 2014) and other drugs (Zeller, Becnel, Reiter-Purtill, Peugh, & Wu, 2016)), depressive symptoms (Anderson, Cohen, Naumova, & Must, 2006; Wilson & Sato, 2014), unhealthy food consumption (Hassapidou, Fotiadou, Maglara, & Papadopoulou, 2006; Receveur, Morou, Gray-Donald, & Macaulay, 2008; Shang, O'Loughlin, Tremblay, & Gray-Donald, 2014; Woodward-Lopez, Kao, & Ritchie, 2010), and television use and computer use/video game play (Hill et al., 2016; Mitchell, Schmitz, Rodriguez, & Audrain-McGovern, 2013; Ray & Jat, 2010; Strasburger, Jordan, & Donnerstein, 2010; Wethington, Pan, & Sherry, 2013).

While some interventions focussing on these individual factors have had some success in reducing overweight/obesity, current research has expanded to examine other contexts that may influence a young person’s weight status, such as that of family and school. In particular, families who are, for example, of lower socio-economic status (SES), may be less able to afford nutrient-rich low calorie foods and are more likely to consume unhealthy, processed foods, resulting in overweight/obesity (Dinsa et al., 2012; Wu et al., 2015). School factors such as experiencing victimisation by peers has also been found to be more prominent in overweight/obese children and adolescents (Puhl et al., 2011; van Geel et al., 2014). This may be the result of weight biases against overweight/obese peers and the development of
negative attitudes towards those who are overweight/obese (Bell & Morgan, 2000; Cramer & Steinwert, 1998; Kraig & Keel, 2001; Neumark-Sztainer & Eisenberg, 2005). This research incorporates EST principles, and has received strong support.

In addition to the development of overweight/obesity, the development of aggressive behaviour that starts in early childhood is known to be heavily influenced by family factors such as SES (Galan, Shaw, Dishion, & Wilson, 2017; Santiago et al., 2011). In contrast, the development of aggressive behaviours that start in late childhood and early adolescence are influenced by a combination of many different contextual and systemic factors outside the family (Simons, Wu, Conger, & Lorentz, 1994). These may include the school, neighbourhood, and peer group, which may include hostile relations with teachers and peers, peer pressure for early delinquent activity, and involvement with gangs or other delinquent peers (Bjerregaard & Smith, 1993; Cernkovich & Giordano, 1992). Aggressive behaviour that begins in adolescence is often characterized less by family characteristics and more by failure at school, the presence of illegitimate opportunities, association with delinquent peers, and in some communities the prestige and illicit money that reward gang membership (Simons et al., 1994). Consequently, the joint contributions of two or more microsystems, such as family and school, can have a powerful impact on the development of positive and negative behaviours in children and youth (Barboza et al., 2009).

Particularly within the school environment, school-related factors such as a teacher’s grading practices, classroom management skills, and teaching strategies exert important environmental influences on a child’s bonding with various aspects of the school and his or her risk of developing aggressive behaviour in early adolescence (O'Donnell, Hawkins, & Abbott, 1995). Within the school, teachers establish rules that guide the social interactions of children with other children (as well as with other adults) and that can determine how rewards are given for academic achievement, including rewards for successful social
participation in study, task, and project groups (Fraser, 1996). Thus, classroom practices that promote positive social development create many opportunities for success for children and adolescents (Fraser, 1996).

It is clear from an EST perspective that a child’s environment plays an unequivocal role in influencing their development. Their interactions with their environment contribute to the development of both adaptive and maladaptive behaviours in children and adolescents (White & Renk, 2012). Childhood stress theories hold that the child’s neurological and physical development can be compromised by early and continual exposure to stress affecting both the development of overweight/obesity and also physical aggression. Inevitably, children are embroiled within multiple systems within an ecological framework, experiencing direct and indirect influences from their families (such as parents, siblings and other relations), their communities (such as schools, peers, other institutions), and their cultures and societies (such as societal values, attitudes, and ethnicity) (White & Renk, 2012). Each of these systems provides important information when examining adolescents’ behaviour problem (White & Renk, 2012). It is also imperative to consider individual factors and characteristics, as these play a pivotal role and will form the basis of their interactions with the various individuals nestled within their own microsystem, mesosystem, and exosystem.

Previous chapters of this thesis reviewed prior studies examining the association between overweight/obesity and physical aggression in the context of child and adolescent development theories. Although prior studies have revealed a consistent association, the theoretical mechanism explaining this association remains unclear, as it is unknown whether the association arises due to shared risk factors. In what follows, an empirical paper is reported to examine whether the association between overweight/obesity and physical aggression is evident in a large Australian sample and is maintained after controlling for common risk factors.
Chapter 5: Article 2: Association between child and adolescent overweight/obesity and aggression in a large Australian population sample

Submitted for publication to Journal of Adolescence

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# AUTHORSHIP STATEMENT

## 1. Details of publication and executive author

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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.)

Conducted the literature search, contributed to the conception of the study and the planning of the analysis, contributed to statistical analysis, contributed to data interpretation and drafted the full manuscript and incorporated the revisions of the other 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

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<tr>
<td>John W. Toumbourou</td>
<td>Principal Investigator, Victoria for the 2006 Healthy Neighbourhoods Project (cross-sectional study that provided data for this study); contributed to the conception of the study, planning, conducting and interpreting the statistical analysis, redrafting and critical revision of the manuscript</td>
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**Joanne Williams**  
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**Belinda L. Guadagno**  
Deakin University, Melbourne, Victoria, Australia  
Contributed to planning; redrafting and critical revision of the manuscript

### 5. Author Declarations

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

- vi. that I have met the authorship criteria set out in the Deakin University Research Conduct Policy,
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<td>Joanne Williams</td>
<td></td>
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</tr>
<tr>
<td>Belinda L. Guadagno</td>
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<td>16 Mar 2018</td>
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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.

7. **Data storage**

The original data for this project are stored in the following locations. (The locations must be within an appropriate institutional setting. If the executive author is a Deakin staff member and data are stored outside Deakin University, permission for this must be given by the Head of Academic Unit within which the executive author is based.)

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<td>Electronic</td>
<td>Deakin University</td>
<td></td>
<td>Professor John Toumbourou</td>
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_The data was obtained by the executive author in de-identified STATA data files. The original data comes from the Healthy Neighbourhoods Project. The Healthy Neighbourhoods custodian for the present project is Professor John Toumbourou from Deakin University._

This form must be retained by the executive author, within the school or institute in which they are based.

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Abstract

Overweight/obesity and engaging in physically aggressive behaviour in childhood and adolescence are two common and important issues that undermine healthy development. The current study sought to ascertain whether an association between overweight/obesity and physical aggression existed independently of a range of shared risk factors. A nationally representative sample of Australian children aged 10-14 years was analysed (N = 7,280) to predict physical aggression from overweight/obesity, adjusting for shared risk factors using multivariate regression. Results from the multivariate analysis yielded a significant association between overweight/obesity and physical aggression (IRR = 1.003, 95%CI = 1.001-1.006, p = .01) after controlling for demographic variables and shared risk factors. Shared risk factors reduced the effect but did not provide a full explanation. These findings support a direct relationship between overweight/obesity and physical aggression in children and adolescents, and do not support the view that this relationship is explained by shared risk factors.
Introduction

Overweight/obesity and engaging in physically aggressive behaviour are important and common co-occurring problems that undermine healthy adolescent development. A systematic review and meta-analysis revealed overweight/obesity in adolescence was consistently associated with physical aggression in prior studies, with an effect size of 0.27 (95% CI: .17-.37) (Tso, Rowland, Toumbourou, & Guadagno, 2017). This review recommended that future research sought to explain this relationship and establish to what extent it arises due to common underlying influences (risk factors) (Tso et al., 2017).

In developmental research, risk factors are identified based on their consistent association with child and adolescent outcomes, maintained after controlling for other known influences. The identification of unique risk factors in multivariate analysis is a preliminary step that can indicate where causal processes may be located (Toumbourou et al., 2014). Given that multiple influences are at play, it is important to test a range of risk factors in order to ascertain whether adolescent overweight/obesity has an independent influence on aggression. The sections that follow summarise research literature that has identified common risk factors for both adolescent overweight/obesity and aggression. These factors are: impulsivity, substance use (including alcohol/tobacco/other drugs), unhealthy food consumption, depressive symptoms, peer victimisation, television and computer use/video game play, and socioeconomic disadvantage.

Impulsivity

Young people high in impulsivity have difficulties with self-control and emotion and behaviour regulation, which may lead to over-consumption of energy-dense food, contributing to an increased overweight/obesity risk (Harrist et al., 2013; Lanza et al., 2014). Associations have also been found between impulsive behaviours and engaging in aggression (Casey, Jones, & Hare, 2008; Fuentes et al., 2016; Hatfield & Dula, 2014; Piko & Pinczés,
2014; Raine et al., 1998; Sarkisian et al., 2017). Casey et al. (2008) provide a neuro-developmental explanation arguing that impulsive young people have increased risk-taking behaviour and greater emotional reactivity in childhood and adolescence, as a result of an under-developed pre-frontal cortex. Similarly, some young people may possess a higher reward-oriented disposition, placing greater importance on short-term rewards, which may also lead to increased likelihood of overweight/obesity (through over-eating), and engaging in physical aggression (Ellis et al., 2012; Volk, Schiralli, Xia, Zhao, & Dane, 2018).

**Substance Use (including Alcohol, Tobacco, and Other Drugs)**

Both overweight/obesity and physical aggression in children and adolescents are associated with alcohol, tobacco, and other drug use. Alcohol presents a significant source of caloric intake with limited or no nutritional value, which results in consumption of excess calories, thus contributing to overweight/obesity (Battista & Leatherdale, 2017; Fazzino et al., 2017). Overweight/obesity has also been linked to tobacco smoking as those who are overweight/obese may use it as a weight loss strategy (Huang et al., 2013; Lanza et al., 2014; Lowry, Galuska, Fulton, Wechsler, & Kann, 2002; Plotnikoff, Loucaides, Karunamuni, Bercovitz, & Rhodes, 2007; Potter, Chan, Aubut, Koval, & Pederson, 2004). Other drugs, such as cannabis, have been shown to stimulate appetite and ingestive behaviours, by acting on these receptors in the brain (Zeller et al., 2016).

The use of these substances has also been linked with engaging in physical aggression. Acute alcohol consumption has been related to changes in prefrontal cortical brain networks and impaired executive function, which can result in lowered inhibitions and therefore an increase in heightened risky and impulsive behaviours which often manifest in the form of physical aggression (Anderson, 2002). Executive dysfunction has been linked to impaired consequential thinking and reduced self-control, thereby increasing the risk of triggering and engaging in aggressive behaviours (Goldstein, 1985; Valdebenito et al., 2015). Frequent
substance use during puberty has also been found to damage the hippocampus and cortices in the brain (in particular, the prefrontal cortex), which do not finish developing until the end of puberty (Bava & Tapert; Nagel, Schweinsburg, Phan, & Tapert, 2005). Damage to the prefrontal cortex may hinder executive function, which includes a range of higher-order cognitive processes (e.g., anticipation, judgement, goal selection, planning, self-regulation, inhibitory control, mental flexibility, decision-making) involved in consequential thinking and the development of higher cognitive functions that may undermine the development of social skills such as conflict management (Clark, Thatcher, & Tapert, 2008). Poor executive function has been linked to an inability to anticipate consequences, difficulty generating socially appropriate behaviours in challenging environments, and the use of physical aggression (Giancola, 1995).

**Depressive Symptoms**

Young people suffering from depressive symptomatology experience cognitive and affective deficits that make them less able to problem solve and regulate behaviour, which has been associated with obesogenic behaviours such as ‘emotional comfort eating’ as a coping mechanism (Anderson et al., 2006), as well as sedentary behaviour because of reduced motivation to engage in daily activities (Hoare et al., 2014; Korczak et al., 2013; Sanders et al., 2015). In reducing physical activity and in some cases increasing calorie intake, depression may increase the likelihood of overweight/obesity (Wilson & Sato, 2014).

Studies have also found a relationship between depressive symptomatology and physically aggressive behaviour (Priddis et al., 2014), though in-depth explorations into this link are lacking. Priddis et al. (2014) suggest that depressed youth have greater difficulties with emotion and behaviour regulation leading to aggression.

**Unhealthy Food Consumption**
The term “junk food” is used to describe packaged and processed foods that are often high in sugar and marketed to young people (Shang et al., 2014). Several studies have found support for a relationship between junk food/soft drink consumption and overweight/obesity in children and adolescents as a result of excess caloric intake (Shang et al., 2014; Woodward-Lopez et al., 2010). Studies have also demonstrated that a deficiency in nutrients and malnutrition can impair neurocognitive functioning, which can lead to aggressive behaviours (Liu, Raine, Venables, & Mednick, 2004; Raine, Yaralian, Reynolds, Venables, & Mednick, 2002). The presence of excess levels of caffeine, sugar, high fructose corn syrup, aspartame, sodium benzoate, and phosphoric/citric acid in these substances affect the human body and place it in a physiological state that can predispose an individual to engage in aggressive behaviour (Solnick & Hemenway, 2011).

**Peer Victimisation**

Research has shown that children as young as three years of age can develop negative attitudes towards overweight/obese peers (Cramer & Steinwert, 1998), and that these weight-related attitudes are also prevalent amongst older children (Bell & Morgan, 2000; Kraig & Keel, 2001) and adolescents (Neumark-Sztainer & Eisenberg, 2005), which can often result in peer victimisation. Children who are victimised may also learn from those interactions and may model aggressive behaviour towards others, particularly if those subsequent actions are positively reinforced by being effective at reducing peer victimisation and facilitating goal attainment such as social status (Ostrov, 2010). Several studies have supported the notion of the use of aggression as a response to peer victimisation, and Kochenderfer-Ladd (2004) found that anger and seeking revenge in the form of physical aggression were common responses to being victimized by peers.

**Television Use, and Computer Use/Video Game Play**
Much research exists suggesting a strong link between television viewing and computer use/video game play and overweight/obesity (Hill et al., 2016; Mitchell et al., 2013; Ray & Jat, 2010; Strasburger et al., 2010; Wethington et al., 2013). There are two main hypotheses with some research support for this link. The first hypothesis (with the most supporting research) relates to an increase in dietary energy intake from eating while viewing media, and includes effects associated with food advertising (Strasburger et al., 2010; Wethington et al., 2013). Television viewing, in particular, can encourage increased caloric intake either from eating during viewing or as a result of food advertising on television, which tends to emphasise high-calorie, high-fat foods with poor nutritional content (Story & Faulkner, 1990), and can be related to children’s requests for, and parental purchases of, highly advertised foods (Taras, Sallis, Patterson, Nader, & Nelson, 1989). While this hypothesised mechanism is clearly appropriate for linking television to children’s obesity, it is less relevant to video games (Vandewater, Shim, & Caplovitz, 2004). The second hypothesis is dubbed the “couch potato” hypothesis, which stipulates that time spent on television use or computer use/video game play displaces physical activities, such as playing outside, facilitating a more sedentary lifestyle for children and adolescents (Strasburger et al., 2010; Vandewater et al., 2004). Results from studies testing this theory have yielded inconsistent results, with some studies finding a relationship (Jordan, Kramer-Golinkoff, & Strasburger, 2009; Jordan & Robinson, 2008; Lajunen et al., 2007), while others have not (Robinson & Killen, 1995).

Exposure to media violence via television watching or playing violent computer/video games has been positively related to subsequent aggressive behaviour, ideas, arousal and anger. A vast amount of research suggests support for links between television and video game use and aggressive outcomes (Busch, de Leeuw, & Manders, 2013; Iannotti, Kogan, Janssen, & Boyce, 2009; Janssen, Boyce, & Pickett, 2012; Kelishadi et al., 2015; Yousef, Eapen, Zoubeidi, & Mabrouk, 2014). These activities affect youth not only by displacing
time they spend doing homework or sleeping but also by influencing beliefs and behaviours, as children and adolescents often learn by observing and imitating what they see on the screen, particularly when these behaviours seem realistic or are rewarded (Strasburger et al., 2010).

**Socio-economic Status (SES)**

Low socioeconomic status (SES) (measured at community level) has been found to correlate with overweight and obesity in children and adolescents in high income countries. While individuals from low income countries face food shortages (which prevent them from becoming overweight/obese), those in middle and high income countries are particularly exposed to the marketing of cheap processed, energy-dense foods (Dinsa et al., 2012; Wu et al., 2015). In high income countries with high levels of inequality, nutrient-rich low calorie foods (such as wholegrain cereals, fruits and vegetables) are less affordable for those of lower SES, resulting in the consumption of more energy-dense foods that are more affordable (such as fast foods) (Dinsa et al., 2012; Wu et al., 2015). In addition, high degrees of urbanisation may affect the availability and accessibility of health-promoting resources (such as public parks, playgrounds, sporting and other facilities that promote physical activity) (Cummins, 2007; Jencks & Mayer, 1990; Leventhal & Brooks-Gunn, 2000), particularly in low-SES neighbourhoods (Igel, Romppel, Baar, Brähler, & Grande, 2016).

A relationship between low neighbourhood SES and aggression in childhood and adolescence has also been identified in a number of studies (Galan et al., 2017; Santiago et al., 2011). Neighbourhoods characterized by economic decline, instability, and decreased family resources are associated with greater adult and adolescent aggression and criminal activity, which may model for youth that aggressive problem-solving strategies and delinquent behaviour are acceptable and even successful behaviours (Farrell & Bruce, 1997). Repeated exposure to expressions of hostility, anger, and distress in the neighbourhood may
facilitate the development of attitudes and beliefs that are favourable to aggression, which likely become consolidated as internal mental representations of distrust and suspicion of others’ intentions (Dodge & Pettit, 2003; Stromquist & Strauman, 1991). These beliefs guide the processing of subsequent information, and for children living in highly deprived neighbourhoods, are likely to facilitate aggressive responses (Galan et al., 2017). Additionally, it is also possible that physical aggression is utilised as an adaptive strategy as a response to hostile and impoverished environments, as a means to secure necessary resources, such as food and accommodation (Ellis et al., 2012; Farrell & Volk, 2017).

Theoretical support for an independent association between overweight/obesity and physical aggression in children/adolescents can be found through evolutionary and social dominance theories. Evolutionary theories explain this association through a prioritisation of reproductive success, achieved by forcefully securing tangible necessities, such as adequate food, shelter, safety status, and mating opportunities (Ellis et al., 2012). Social dominance theories share similar premises but extend evolutionary theories by providing applicability to a contemporary context, where dominance behaviours begin in childhood with the securing of possessions (such as toys) (Smith & Connolly, 2010), and in adolescence extends to asserting dominance over others with the intention of gaining the favour of peers and potential sexual partners (Brooks-Gunn & Furstenberg, 1989; Dane, Marini, Volk, & Vaillancourt, 2017; Pellegrini & Bartini, 2001).

Ecological Systems Theory (EST) (Bronfenbrenner, 1979; 1994) can be used as a framework to organise research assessing predictors of aggression in childhood and adolescence. Specifically, the effect of overweight/obesity (assessed as body mass index: BMI) on aggression will be examined in the current study. Of specific interest is whether the effect of BMI on aggression is maintained after controlling for the influence of shared “micro-environmental” risk factors such as impulsivity, alcohol use, tobacco use, other drug
use, depressive symptoms, television use, and computer use/video game play. The present study also sought to control for more distal “macro-environmental” risk factors from the family and home environment, such as junk food/sugar consumption, peer victimisation, and neighbourhood disadvantage.

To investigate these associations analyses were completed utilising a large (N = 7,280) representative sample of Australian primary and secondary school children surveyed across three states in Australia (Victoria, New South Wales, and Queensland). It was hypothesised that there would be an independent association between BMI and aggression in children and adolescents, after controlling for common risk factors.

Methods

Sample and Study Design

Data used in this study were collected through the Healthy Neighbourhoods Project, a cross-sectional survey examining the health and wellbeing of students from 30 communities across three states in Australia: Victoria, Queensland, and Western Australia in 2006. The measures were based on the Communities That Care Youth Survey, an epidemiological assessment instrument that was developed in the United States (Arthur, Hawkins, Pollard, Catalano, & Baglioni Jr, 2002), and adapted for Australian youth populations (Beyers, Toumbourou, Catalano, Arthur, & Hawkins, 2004; Hemphill et al., 2010). The Australian survey scales demonstrate similar reliability to US populations, with Cronbach’s alpha coefficients for multi-item scales generally above .70 (Kelly et al., 2011).

Across the 30 communities, school surveys were conducted with grade six and grade eight students. The ages of the participants ranged between 10-16 years. 231 schools elected to participate (61% government, 22% independent, and 17% Catholic). The community sampling frame consisted of Statistical Local Areas (SLA’s; an Australian Standard Geographic Classification structure consisting of non-overlapping spatial units (Australian
Bureau of Statistics, 2006) with greater than 17,000 inhabitants). These SLAs were stratified into quartiles of socioeconomic disadvantage based on Socio-Economic Indexes for Areas (SEIFA) calculated from the population census. Eligible communities were randomly selected from SEIFA quartiles to represent state distributions in advantage/disadvantage and urban and non-urban locations. Quartile 1 represented the most disadvantaged areas, and quartile 4 identified the most advantaged.

A random selection of schools in the selected areas were invited to participate in the survey, and the final sample included eight communities in each of Queensland and Western Australia, and 14 communities in Victoria. Across the 30 communities, 8,256 of the eligible students consented and participated in the survey, representing approximately 54% of the students approached. As a check on the reliability of responses, the questionnaire included a question about the use of a fictitious drug and another question asking each participant how honest they were in filling out the survey. Participants who reported using the fictitious drug or dishonesty were excluded from the analyses (n = 151). A further 825 participants were excluded because of missing data on one or more key variables. The final analysis data set consisted of 7,280 children aged 10-14 years (mean = 11.58 years, SD = 0.81).

Standard data collection protocols were followed in each state, approved by the University of Melbourne’s Human Research Ethics Committee (Vic), the Griffiths University Human Research Ethics Committee (QLD), and the Curtin University of Technology Human Research Ethics Committee (WA). Approvals were also obtained from the relevant governing school authorities in each state. Students participated only if they assented and signed parental consent was given. The survey was web-based and completed during school class time during a 45-60 minute period, and paper copies of the survey were provided if computer resources were not available. Basic physical health measurements of height, weight, and blood pressure were also taken.
**Measures**

**Dependent variable**

**Aggression**

The dependent variable was an ordinal count variable created to identify the number of occasions that participants reported having engaged in physically aggressive behaviour in the last 12 months. This variable aggregated responses from two items on the survey which asked how many times in the past year respondents had: ‘attacked someone with the idea of seriously hurting them’, or ‘beat up somebody so badly that they probably needed to see a doctor or nurse’ ($\alpha = 0.64$). Response options were provided on a 5-point scale, including ‘never’ (0), ‘1 or 2 times’ (1), ‘3 to 5 times’ (2), ‘6 to 9 times’ (3), and ’10 or more times’ (4).

**Independent variable**

**Body mass index (BMI)**

Participants’ heights and weights were directly measured by trained research staff with standardised equipment and procedures (Williams, Canterford, Toumbourou, Patton, & Catalano, 2015). Body mass index was calculated by utilising the following formula: weight (in kilograms)/height (in meters)$^2$. Sex- and age-specific cut-off points for not overweight, overweight, and obesity were taken from the model developed by the International Obesity Task Force (IOTF) (Cole, Bellizzi, Flegal, & Dietz, 2000).

**Impulsivity**

Measured by three items: ‘It is important to think before you act’, ‘I rush into things, starting before I know what to do’, and ‘I answer without thinking about it first’. Response options were: ‘YES!’, ‘yes’, ‘no’, and ‘NO!’.

**Alcohol/tobacco/other drug use**

Measured by asking respondents if, in their lifetime, they had ever: smoked cigarettes; had more than just a few sips of an alcoholic beverage; used marijuana; sniffed glue, breathed
the contents of an aerosol spray can, or inhaled other gases or sprays, in order to get high; used other illegal drugs (like cocaine, heroin, ecstasy, or amphetamines/speed); used stimulants (speed, amphetamines, uppers, meth, crystal, crank); used ecstasy (XYC, E, X, MDMA, eccies, dove); used heroin (bomb, H, smack, junk); or used other illegal drugs. Response options ranged from ‘Never’ to ‘10 or more times’.

**Depressive symptoms**

The Short Mood and Feelings Questionnaire (SMFQ) (Angold, Costello, Messer, & Pickles, 1995) was incorporated, comprising 13 questions about negative mood, feelings and behaviours in the past 2 weeks. Participants could answer questions as either ‘True’ (=2), ‘Sometimes true’ (=1) or ‘Not true’ (=0). Scores on the 13 questions were summed for each participant, and total SMFQ scores ranged from 0 (indicating complete absence of depressive symptomatology) to 26.

**Unhealthy food consumption**

Measured with items asking participants how many serves of the following foods were eaten daily: hamburgers, hot dogs, sausages, potato crisps/savoury snacks, biscuits, donuts, cake, pie, chocolate, sweet drinks (such as soft drinks, cordial, Big M, flavoured mineral water, etc.), with six response options ranging from ‘None’ to ‘5 or more’, as well as how often they usually ate food from a takeaway/fast food outlet (such as McDonalds, KFC, Hungry Jacks, Subway, fish and chips, hamburgers, etc.), with six responses ranging from ‘Less than once a month’ to ‘Most days’.

**Peer victimisation/rejection**

Measured by asking participants whether they had ‘been bullied recently (teased or called names, had rumours spread [about them], been deliberately left out of things, threatened physically, or actually hurt’. Responses were measured on a four-point scale from ‘No’ to ‘Yes most days’.
Television use and computer use/video game play

Measured by hours per day participants watched television, on school days and on weekend days. Computer use/video game play were measured by hours per day spent on a computer or playing video games such as Gamecube, xBox, PS2, PSP, GBA, etc. on school days and weekend days. Response options ranged from ‘None’ to ‘more than 6 hours’.

Control variables

To adjust for confounding effects, demographic controls included gender, age, and SES (measured by SEIFA disadvantage quartile).

Analysis

Data analyses were performed using Stata/MP 14.0 statistical software (StataCorp, 2015). As the dependent variable of aggression is a count indicator with a highly skewed distribution, a modified Poisson regression analysis (Poisson regression with robust standard errors (Zou, 2004)) was used to model incidence rate ratios (IRRs). These analyses examined the prediction of aggression from BMI, with control of covariates for age, gender, and SES. This analysis was chosen for the following reasons: firstly, the dependent variable (aggression) was not normally distributed and was a count variable that fitted the Poisson distribution. Secondly, negative values for the outcome variable were not possible and the results were bound by a maximum score. Covariates (including age, gender, SES, impulsivity, alcohol/tobacco/other drug use, depressive symptoms, junk food consumption, peer victimisation, television use, and computer use/video game play were added in a final multivariate regression model in order to assess whether BMI maintained an effect on aggression, after adjusting for other predictors.

As the data were of a clustered nature (individual schools clustered within Statistical Local Areas), adjustments were incorporated into analyses using the STATA ‘svy’ command. The assumption was that respondents within schools would share similar characteristics and
would violate conventional respondent independence assumptions. As the clustering is low, the ‘svy’ adjustment will not have a large effect on estimates.

Results

Table 1 summarises the characteristics of the sample. Table 2 presents Pearson correlations between aggression, body mass index (BMI), demographic variables, and covariates. Higher levels of aggression were correlated with all of the independent measures: male gender, increasing age, membership in a lower SEIFA disadvantage quartile, and higher levels of impulsivity, alcohol use, tobacco use, other drug use, depressive symptoms, junk food/sugar consumption, and peer victimisation. Table 3 presents a summary of the multivariate poisson regression analysis of the association between BMI and contains both the unadjusted model (including only demographic variables) and the full adjusted model, which included demographic variables as well as covariates. In the partially unadjusted Model 1, a significant association was found between BMI and aggression (IRR = 1.005, 95 percent Confidence Interval [95%CI] = 1.002-1.007, p = .001). In the fully adjusted Model 2, controlling for all the predictors listed in Table 2, the association between BMI and aggression was still found to be significant (IRR = 1.003, 95%CI = 1.001-1.006, p = .01, F(4,227) = 36.77, p < .000), albeit reduced in magnitude. All demographic variables and covariates remained significantly associated with aggression in Model 2, aside from SES (IRR = 0.994, 95%CI = 0.988-1.001, p = .121) and peer victimisation (IRR = 1.003, 95%CI = 0.993-1.013, p = .526) and television use (IRR = 0.999, 95%CI = 0.990-1.001, p = .794) which were not significantly related to aggression.

Table 1. Demographic characteristics for the overall sample (n = 7,280)

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<tr>
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<tr>
<td>Female</td>
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<tr>
<td>Age (Years)</td>
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<td>10</td>
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**SEIFA Disadvantage Quartile**
- **First (most disadvantaged)**: 2,029 (27.87)
- **Second**: 1,791 (24.60)
- **Third**: 1,706 (23.43)
- **Fourth (least disadvantaged)**: 1,754 (24.09)
Table 2. Pearson correlations between aggression, body mass index (BMI), demographic variables, and covariates: 7,127 participants assessed in childhood or adolescence

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<td>0.074***</td>
<td>-0.078***</td>
<td>0.088***</td>
<td>-0.066***</td>
<td>0.168***</td>
<td>0.123***</td>
<td>0.103***</td>
<td>0.062***</td>
<td>0.116***</td>
<td>0.322***</td>
<td>0.067***</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>0.127***</td>
<td>0.042***</td>
<td>-0.239***</td>
<td>0.100***</td>
<td>-0.053***</td>
<td>0.186***</td>
<td>0.154***</td>
<td>0.095***</td>
<td>0.075***</td>
<td>0.131***</td>
<td>0.307***</td>
<td>0.064***</td>
<td>0.403***</td>
</tr>
</tbody>
</table>

*Key: (1) Aggression, (2) Body Mass Index, (3) Gender, (4) Age, (5) SES (measured by SEIFA disadvantage quartile), (6) Impulsivity, (7) Alcohol use, (8) Tobacco use, (9) Other drug use, (10) Depressive symptoms, (11) Unhealthy food consumption, (12) Peer victimisation (13) Television use, (14) Computer use and video game play

*p < .05, **p < .01, ***p < .001
Table 3. Multivariate Poisson regression analyses predicting aggression in children and adolescents from BMI and covariates

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Model 1</th>
<th></th>
<th>Model 2</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IRR</td>
<td>95% CI</td>
<td>IRR</td>
<td>95% CI</td>
</tr>
<tr>
<td>BMI</td>
<td>1.005</td>
<td>1.002-1.007</td>
<td>1.003</td>
<td>1.001-1.006</td>
</tr>
<tr>
<td>Gender (Female Sex)</td>
<td>0.900</td>
<td>0.884-0.916</td>
<td>0.919</td>
<td>0.904-0.935</td>
</tr>
<tr>
<td>Age</td>
<td>1.002</td>
<td>0.991-1.013</td>
<td>0.984</td>
<td>0.974-0.995</td>
</tr>
<tr>
<td>SES (measured by SEIFA disadvantage quartile)</td>
<td>0.991</td>
<td>0.984-0.998</td>
<td>0.994</td>
<td>0.988-1.001</td>
</tr>
<tr>
<td>Risk Factors</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Impulsivity</td>
<td>1.047</td>
<td>1.029-1.066</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Alcohol use</td>
<td>1.028</td>
<td>1.019-1.038</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tobacco use</td>
<td>1.027</td>
<td>1.006-1.047</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other drug use</td>
<td>1.143</td>
<td>1.068-1.224</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Depressive symptoms</td>
<td>1.005</td>
<td>1.003-1.007</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Junk food/sugar consumption</td>
<td>1.026</td>
<td>1.005-1.034</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Peer victimisation</td>
<td>1.003</td>
<td>0.993-1.013</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Television use</td>
<td>0.999</td>
<td>0.990-1.008</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer use and video game play</td>
<td>1.010</td>
<td>1.001-1.020</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

IRR = Incidence Rate Ratio. 95% CI = 95 percent Confidence Interval. Model 1 = Multivariate regression partially adjusted for the demographic factors. Model 2 = Fully adjusted for all predictors.

Bolded values are statistically significant at p < .05

Discussion

The primary aim of this study was to examine the association between overweight/obesity and physical aggression in children and adolescents, and to ascertain whether associations were maintained after controlling for shared risk factors. To the authors’ knowledge, this is the first study in the empirical literature investigating this research question. In line with the hypothesis, this study identified a significant association between overweight/obesity and physical aggression in children and adolescents aged 10-14 years, and this association remained significant after controlling for the common risk factors. The association between overweight/obesity and physical aggression was consistent with findings of previous studies (Eschenbeck et al., 2009; Griffiths et al., 2006; Janssen et al., 2004; Liu et al., 2016; Raine et al., 1998; Reyhani & Bozorgi, 2016; Sawyer et al., 2006; Zeller et al., 2008). The current study has
provided an important contribution to the extant research literature by demonstrating that overweight/obesity remains a significant predictor of aggression after controlling for a range of common risk factors.

In the unadjusted multivariate analysis, BMI, gender and SES were significantly related to aggression, while age was not. In the adjusted multivariate analysis, it was found that BMI, gender, age, impulsivity, alcohol/tobacco/other drug use, depressive symptoms, junk food/sugar consumption, and computer use/video game play all maintained significant relationships with aggression. These findings lend support to the ecological systems model in suggesting that aggression is influenced by a wide range of risk factors. Contrary to extant research, however, the results of this study found non-significant multivariate relationships between aggression and SES, peer victimisation, and television use, despite significant associations found between each of these factors with aggression in the separate Pearson correlation analysis. These findings suggest that the influence of these risk factors is indirect and may be explained more directly by other factors included in the analysis.

Implications for Theory

The majority of our results supported existing theories around risk factors associated with aggression in children and adolescents.

The finding that the influence of SES on aggression was indirect aligns with some prior research, which has found that other factors may affect the relationship between neighbourhood disadvantage and physical aggression. For example, Sarkisian et al. (2017) found a significant association between impulsivity and physical aggression in their longitudinal study spanning childhood (7-8 years) to adolescence (13-18 years), after controlling for SES. In another study, Santiago, Wadsworth, and Stump (2011) found that poverty-related stress was directly related to
depressive symptoms, which subsequently led to externalising behaviours in children and adolescents. Similarly, Heshmat et al. (2016) found in their nationally representative sample of 14,880 children and adolescents aged 6-18 years, that youth classified as being in the low SES group were significantly more likely to experience feelings of worthlessness and depression, as compared to those in the high SES group. As these emotional factors were controlled for in the current study together with SES, it is plausible that the relationship that initially existed between SES and aggression was subsequently explained by other factors in our analysis.

The current findings highlight the potential indirect impact that the school location can have on adolescent behaviour. This influence may operate by affecting more direct influences in areas such as: the spatial distribution of friendship circles, the quality of teachers, and school climate. These factors may in-turn influence the more proximal attitudes and behaviour of students independently of the residential neighbourhood context, further emphasising the importance of the interactions within a child’s ecosystem (Bronfenbrenner, 1979; 1994).

The results of the current study also found that the relationship between peer victimisation and aggression was no longer significant in the adjusted model, suggesting that peer victimisation may operate indirectly on aggression. Studies have found that children or adolescents who have been victimised by peers often develop depressive symptoms, which is associated with physical aggression (Hoare et al., 2014; Kaltiala-Heino & Fröjd, 2011). As such, it is possible that as depressive symptoms were also controlled for in our study, the strength of the relationship between peer victimisation and aggression may be attenuated.

Lastly, the results from the adjusted analysis in the current study did not find a significant association between television use and aggression, despite there being a significant association between computer use/video game play and aggression. An explanation for this result may be
that as television use is significantly correlated with computer use/video game play ($r = 0.403, p < .001$), the relationship is mostly explained by the inclusion of computer use/video game play as a separate covariate in this analysis. Adolescent television use habits may lead to an increased interest in computer use/video game play, and it could be that computer use/video game play more directly influences aggression than television use. Additionally, information regarding the content accessed during television use and computer use/video game play was not measured, and levels of aggression could differ depending on the material that was viewed by the participants.

**Directions for Future Research**

The results of this study extend the current research literature regarding the association between overweight/obesity and physical aggression in children and adolescents. This association remained significant even after controlling for a variety of common risk factors, and lends further support for the notion that an independent association exists between overweight/obesity and physical aggression independently of shared risk factors. This association could be explained by Evolutionary and Social Dominance theories which propose that overweight/obese adolescents display aggression as a means of establishing reputations (of strength and dominance) both within peer groups and with potential sexual partners (Archer & Benson, 2008), and as a means of gaining material resources (such as nutrition and shelter) (Kolbert & Crothers, 2003). Future studies should examine direct causal processes between these variables.

The current study has provided further support for a direct effect of varied risk factors as influences on physical aggression in childhood and adolescence. Future studies could further evaluate these risk factors as prevention targets within school and community trials, with an aim to extend knowledge in aggression prevention and intervention literature to inform early
intervention program development. Early intervention to prevent aggression using a wide range of risk factor measures may be warranted to protect children and adolescents from aggression and other health and social problems by targeting high-risk groups in the initial stages of overweight and obesity, and again at subsequent signs of impulsivity, depressive symptoms, alcohol/tobacco/other drug use, excess unhealthy food consumption, and excess computer use/video game play.

Lastly, in the multivariate analysis, neighbourhood disadvantage, peer victimisation, and television use were not significantly related to aggression, contrary to previously outlined research. Several explanations for these findings were offered. It is noteworthy that these factors operate as proximal influences in ecological systems theories of aggression and, hence by demonstrating indirect effects for these factors, the current study provides some support for these theories. Future studies should continue to empirically verify comprehensive ecological models of adolescent aggression.

**Limitations**

Although results from this study implied higher levels of aggression among children or adolescents with higher BMIs, the design was cross-sectional and hence cannot address the issue of causality. To better establish causation, future studies with longitudinal and intervention designs could examine the effect on aggression of preventing either overweight/obesity or their common determinants. These analyses examined the independent effect on aggression of BMI and risk behaviours. It was found that there was a significant independent effect on aggression of both BMI and risk factors such as depressive symptoms, alcohol/tobacco/other drug use, impulsivity, and unhealthy food consumption. However, the design has not examined the
possibility of complex reciprocal relationships. Additional longitudinal studies are needed to disentangle potential reciprocal relationships between aggression and overweight/obesity.

A limitation of using BMI as the sole indicator of overweight/obesity as a cause of aggression is the fact that it only measures the overall height and weight of the individual. Other physical factors that may affect an individual’s aggression, such as muscle mass, are not considered. Indeed, some studies have demonstrated that BMI may be positively correlated with increased muscle strength (and therefore, mass) (Ervin, Fryar, Wang, Miller, & Ogden, 2014; Gallup et al., 2007; Hasan et al., 2016). As such, measures of waist circumference (Aeberli et al., 2013; Freedman & Sherry, 2009) and skinfold thickness tests (Freedman & Sherry, 2009) conducted in addition to a calculation of BMI would increase the sensitivity and accuracy of measurements of overweight/obesity as a cause of aggression in future research.

A final limitation of this study was the fact that the outcome variable measured high levels of physical aggression, to the extent of inflicting serious injury upon another that required medical attention, and did not accommodate outcomes that may be on a lower end of the physical aggression spectrum, such as threats to harm, or pushing/shoving. Future studies could incorporate a wider range of physically aggressive outcomes that incorporate lower levels of physically aggressive behaviours.

**Conclusion**

Notwithstanding the limitations identified above, this study confirms prior research and concludes there is a significant association between BMI and aggression in children and adolescents. This association was maintained in multivariate analyses controlling for a range of shared risk factors. Given the many adverse physical, social, and psychological effects upon children and adolescents who are overweight/obese or aggressive, it would be pertinent for
further longitudinal and intervention research to be conducted to specify the potential causal models, and to explore factors that may be of a protective nature against this association.
Chapter 6: Protective factors that reduce physical aggression in overweight/obese children and adolescents

Previous chapters of this thesis identified that the significant association between overweight/obesity and adolescent physical aggression was not explained by common risk factors; however, the magnitude of this association was reduced when these risk factors were controlled in multivariate analyses. The chapter that follows reviews research to examine the extent to which the association between overweight/obesity and physical aggression, might be reduced by protective factors that arise in resiliency theories. The chapter begins by examining how the adolescent transition has been conceptualised within stress theories. An examination of how stress theory has been used to develop varied resiliency theories follows. The chapter ends with an examination of studies that have measured protective factors for adolescent overweight/obesity and physical aggression.

The Adolescent Transition and Stress Theories

As life events and major changes disrupt stable adaptive patterns, they have the potential to be stressful. Adolescence is a period accompanied by major physical and psychological changes that alter young children’s relationships and patterns of interaction with others. The transition into adolescence begins the move towards independence from parents. This change introduces demands to establish one’s own values, personal and sexual identity, and the skills and competencies needed to successfully participate in adult society (Mann & Yadav, 2016). Independence requires young people to re-negotiate family rules and supervision, which can often result in conflicts and withdrawal from parents (Mann & Yadav, 2016). Adapting to the process of changes in their family relationships, and transitioning into new peer social contexts has the potential to generate stress, feelings of rejection, anger, hostility and aggression during
the adolescent period when adaptive emotion regulation and coping skills are not yet fully
developed and learned (Mann & Yadav, 2016). Early adolescence is an important time to study
the application of stress theories to aggression, because it is a time of significant transition that
has the potential to be stressful for some young people (Eccles et al., 1993).

The transition from primary to secondary school can be particularly tumultuous for some
young people. Secondary schools typically provide less individualised support, as they are larger
and more anonymous than primary schools (Eccles et al., 1993). Increased bureaucracy and
restrictions on behaviour may cause frustration for adolescents who, developmentally, are
striving to become more autonomous (Eccles et al., 1993). Furthermore, the social climate can
vary in secondary school and in some cases promote social norms that reward rule-breaking or
aggressive behaviour. Exposure to some school environments may trigger conflicted internal
states for young adolescents, oscillating between respecting authority and wishing to conform to
(and impress) peers in order to establish independent identities (Cushing, Horner, & Barrier,
2003).

Ecological models propose that developmental transitions such as adolescence can be
understood within stress theory by examining the dynamic interactions between personal
characteristics and the surrounding social and physical environment (Crockett & Crouter, 2014;
Magnusson & Stattin, 2006). Through observation and interpersonal interactions at home, with
peers, and in the community, adolescents develop patterns of behaviour based on what they
perceive to be appropriate and inappropriate (Bernburg & Thorlindsson, 2005). In addition to the
complexity of these normal transitional processes experienced by children and adolescents
during this developmental period, some may be classified at a higher risk of negative effects of
transitional stress because of additional hardships present in their lives (Rak & Patterson, 1996).
Poverty, violence, substance abuse, neighbourhood disadvantage, and mental and physical illness represent a few potential vulnerabilities, which were explored in the previous Chapters.

There are, however, many children and adolescents who encounter stress and adversity in life and fair well despite their exposure to severe challenges (Alvord & Grados, 2005; Brooks, 2006; Masten, 2007, 2011; Masten, Best, & Garmezy, 2008; Masten & Coatsworth, 1998; Rak & Patterson, 1996). Not all aggressive, oppositional, and socially troubled children and adolescents become violent delinquents. This suggests that there may be compensatory or protective factors that counterbalance or mitigate the transition stress for some youth that are at-risk based on their behavioural and socio-demographic profiles (Fontaine et al., 2016). Children who succeed across stressful adaptations in spite of initial adversity have been identified as “resilient”. This is defined as possessing certain strengths or “protective factors” that help them overcome adverse conditions and continue to thrive (Zolkoski & Bullock, 2012).

From the ecological systems theory (EST) perspective, many risk and protective factors that affect the adolescent transition arise in social systems such as the family, peer group, and community. These social systems provide constant opportunities for adolescents to be exposed to values, norms, and behaviours that promote either problem behaviours or healthy and socially competent adjustment (Magnusson & Stattin, 2006). The dynamic social system interactions provide the foundation for adolescent development, with the most influential interactions being those that occur regularly, over an extended period of time, and between people with strong and mutual bonds (Bronfenbrenner & Morris, 1998).

**Models of Resilience**

Research into resilience in children and adolescents began through studies of children with mothers suffering from schizophrenia (Garmezy, 1974; Garmezy & Streitman, 1974; Masten et
Evidence that many of these children thrived, despite their high-risk status led to empirical efforts to understand individual variations in response to adversity (Luthar, Cicchetti, & Becker, 2000). Early efforts were primarily focused on internal and individual qualities that ‘resilient’ children possessed, such as autonomy or high self-esteem. As work in the area evolved, researchers increasingly acknowledged that factors external to the child, such as aspects of their families and characteristics of their wider social environments contributed to levels of resilience (Masten & Garmezy, 1985; Werner & Smith, 1992). With continued research, it became clear that positive adaptation despite exposure to adversity involved a developmental progression, such that new vulnerabilities and strengths often emerged with changing life circumstances (Masten & Garmezy, 1985). This shed some light into how children exposed to dangerous environments and to threatening life events were able to continue to strive to make positive adaptations in response to such stressors (Garmezy, 1991). As such, the foundation of resilience is not understood as an imperviousness to stress, but rather the capacity for recovery through adaptive behaviour that may follow an initial retreat or incapacity upon encountering a stressful event (Garmezy, 1991). Resilience is therefore the ability of individuals to survive and thrive despite exposure to negative circumstances, and refers to dynamic processes encompassing positive adaptation within the context of significant adversity (Hollister-Wagner et al., 2001). Implicit within this notion are two critical conditions that must be satisfied: firstly, exposure to significant threat or severe adversity, and secondly, the subsequent achievement of positive adaptation despite the interference with the developmental process (Garmezy, 1990; Luthar & Zigler, 1991; Masten et al., 2008; Rutter, 1990; Werner & Smith, 1992).
Resiliency theory posits that a variety of factors in childhood and adolescence influence the likelihood of an individual’s participation in behaviours that can either positively or negatively affect their health and well-being (Stoddard et al., 2013). Though it is concerned with risk exposure among children and adolescents, resilience theory is focused primarily on strengths rather than deficits by focussing on understanding healthy development in spite of risk exposure (Fergus & Zimmerman, 2005). As outlined in the previous Chapter, risk factors are defined as conditions or circumstances that the child or adolescent are subject to (or are part of), that are associated with a higher likelihood of negative outcomes (Kazdin, Kraemer, Kessler, Kupfer, & Offord, 1997). Protective (also described as promotive) factors, on the other hand, operate to enhance healthy development in children and adolescents by helping youth overcome the negative effects that risk factors may pose on development. These factors help compensate for or protect against the effects of long-term negative effects on the child’s development by altering responses to the adverse events during adolescence (Fergus & Zimmerman, 2005; Stoddard et al., 2013; Zolkoski & Bullock, 2012). Resilience is optimized when protective factors are strengthened at all interactive levels of the young person’s socio-ecological system: the individual, family, school and community levels (Benzies & Mychasiuk, 2009).

In what follows four models of resiliency are outlined that have been proposed in current research: the compensatory model, the risk-protective model, the protective-protective model, and the challenge model. These models seek to explain how individual and environmental factors function to reduce or offset the adverse effects of risk factors (Brook, Whiteman, Gordon, & Cohen, 1986; Fergus & Zimmerman, 2005; Garmezy, Masten, & Tellegen, 1984; Luthar et al., 2000; Rutter, 1985; Zimmerman & Arunkumar, 1994). These models also explain how
promotive factors operate to alter the trajectory from risk exposure to negative outcome (Garmezy et al., 1984; Rutter, 1985; Zimmerman & Arunkumar, 1994).

**The Compensatory Model**

According to Garmezy et al. (1984), a compensatory factor neutralizes exposure to risk without any interaction with the risk factors; instead, it has a direct and independent influence on the outcome (Fergus & Zimmerman, 2005; Zimmerman & Arunkumar, 1994). In this model, risk factors and protective factors combine additively to predict outcomes. The protective factor is conceived as promoting a counteracting influence operating in an opposite direction to a risk factor (Hollister-Wagner et al., 2001). Children and adolescents that are overweight/obese, for example, may experience higher levels of impulsivity, that may increase the likelihood of engaging in violent behaviour (Casey et al., 2008; Fuentes et al., 2016; Hatfield & Dula, 2014; Piko & Pinczés, 2014; Raine et al., 1998; Sarkisian et al., 2017), however, having a positive attachment to parents may help compensate for peer risk factors (Arim, Dahinten, Marshall, & Shapka, 2011).

**The Challenge Model**

In the challenge model, a stressor is treated as a possible enhancer of individual competence, provided that the amount of stress is not extreme (Garmezy et al., 1984). According to Zimmerman and Arunkumar (1994), the balance in levels of stress in this model is crucial: too little stress is not sufficiently challenging, high levels leave the individual helpless resulting in potential maladaptation. Moderate levels of stress are considered to provide the individual with a challenge that, when overcome, strengthens competence.

This model of stress can be used to understand how protective factors “mediate” the effect of a risk factor. The assumption that protective factors related to individual competence are
stimulated by moderate levels of risk underlies this model. In this model, adolescents exposed to moderate levels of a risk factor may learn how to overcome it as long as they are not exposed to severe levels of a risk factor such that overcoming it is impossible (Fergus & Zimmerman, 2005). A vital point concerning the challenge model is that low levels of risk exposure may be beneficial because they stimulate youth to practice skills or employ resources to elicit a coping response. The adolescent coping response may thus act as a mediator overcoming the effect of the risk factor (Fergus & Zimmerman, 2005).

In challenge models, whether a risk factor is promotive of competence depends on the level of exposure, leading to potential non-linear influences of risk factors (Fergus & Zimmerman, 2005). Too little family conflict for example, may not prepare youth with an opportunity to learn how to cope with or solve interpersonal conflicts outside of the home, yet, too much conflict may be debilitating and lead youth to feel hopeless and distressed (Fergus & Zimmerman, 2005). A moderate amount of conflict, however, may provide youth with enough exposure to learn new “coping skills” to resolve future conflict (Fergus & Zimmerman, 2005). When a young person successfully learns coping skills, their repertoire of protective factors is strengthened, thus preventing expression of the negative outcome in future exposure to risk (Hawkins, Catalano, & Miller, 1992; Pollard, 1989; Rutter, 1987; Sugland, Zaslow, & Nord, 1993). As such, children and adolescents who are overweight/obese may be less likely to engage in physical aggression if they have effective coping skills and strategies (Eisenberg, Fabes, Guthrie, & Reiser, 2000; Southam-Gerow & Kendall, 2002).

The Protective Factor Model

In the protective factor model, Garmezy et al. (1984) explained that there is a conditional relationship between stress and personal attributes, which can dampen or amplify the impact of
stress as a variable with respect to adaptation. Specifically, protective factors (such as assets or resources) can interact with risk factors and moderate or mediate the effects of a risk factor on a negative outcome. A protective model exists if, for example, the relationship between overweight/obesity and physical aggression is reduced for youth with high levels of parental attachment, as parental attachment operates as a protective factor because it moderates the effects of overweight/obesity on aggressive behaviour (Kapoor & Tung, 2017; Murphy et al., 2017; Resnick et al., 2004; Smokowski et al., 2017; Taylor et al., 2016). This model consists of four sub-categories.

**The Protective-Stabilising Model.**

The protective-stabilising model refers to instances when a protective factor helps to neutralise the effects of risk factors. In statistical theory the protective factor moderates the influence of the risk factor. Higher levels of risk are associated with higher levels of a negative outcome when the protective factor is absent, but the relationship between the risk and the outcome when the protective factor is present is negated (Luthar et al., 2000). For example, among youth who are overweight/obese, those with high levels of positive family interactions (family connectedness) may be less likely to exhibit physically aggressive behaviours (Gomez, Gomez, DeMello, & Tallent, 2001; Heidgerken, Hughes, Cavell, & Willson, 2004; Kliewer et al., 2004; Kliewer et al., 2006). In cases where family connectedness was enduring, the protective effect may completely neutralise the risk factor effect.

**The Protective-Reactive Model.**

According to (Luthar et al., 2000), the protective-reactive model refers to instances when a protective factor diminishes, but does not completely remove, the expected correlation between a risk factor and an outcome. Thus, the relationship between the risk factor and the outcome is
significantly stronger when the protective factor is absent. In the language of statistics, the protective factor is conceived as partially moderating the risk factor. Although the protective factor does not completely remove the association between the risk factor and outcome, the correlation is measurably weakened by the presence of the protective factors (Luthar et al., 2000). For example, overweight/obese children and adolescents may be more likely to engage in physically aggressive behaviour, but this relationship may be diminished among those who regularly attend school (Rocque, Jennings, Piquero, Ozkan, & Farrington, 2017; Simons-Morton et al., 2004).

**The Protective-Protective Model.**

In the protective-protective model, Brook et al. (1986) proposed that protective factors can each have unique effects that operate cumulatively in reducing the probability of negative outcomes. This model posited that the strength of the relationship between risk factors and outcomes will decrease with each additional protective factor. For example, the protective-protective model would suggest that having strong parental attachment (Kapoor & Tung, 2017; Murphy et al., 2017; Resnick et al., 2004; Smokowski et al., 2017; Taylor et al., 2016), combined with high levels of emotion control (Cooley & Fite, 2016; Sullivan et al., 2010) would reduce the association between overweight/obesity and physical aggression in children and adolescents more than either protective factor would alone. Critics of this model argue, however, that because resilience theory requires the presence of risk environments where multiple protective factors are less common, this model may be contentious as a resilience-based model (Zolkoski & Bullock, 2012).

Resilience research is somewhat limited because it typically includes single risk factors and a single protective factor (Wong, Eccles, & Sameroff, 2003), while most youth are actually
exposed to multiple risk and protective factors. Several researchers have found that risk and protective factors do not operate independently rather mutually and reciprocally influence each other (Newcomb & Felix-Ortiz, 1992; Olsson, Bond, Burns, Vella-Brodrick, & Sawyer, 2003; Serbin & Karp, 2004). Research to understand resilience processes therefore necessitates analyses that include a range of risk and protective factors (Cicchetti & Rogosch, 2002). As applied to the present thesis, these considerations suggest that protective factors should be tested within multivariate models that examine whether their effects are maintained after controlling for other risk and protective influences.

**Contributors to Childhood/Adolescent Resilience**

The promotive factors that can help youth avoid the negative effects of risk factors may be considered as a combination of assets and resources (Fergus & Zimmerman, 2005). Assets are the positive factors that reside within the individual, such as competence, coping skills, and self-efficacy, whilst resources are factors external to the individual, such as parental support, adult mentoring, or community organisations that promote positive youth development (Fergus & Zimmerman, 2005). Resources emphasise the social environmental influence on adolescent development. This construct aligns with EST in placing resilience theory in an ecological systems context, and moves away from a conceptualisation of resilience as a static, individual trait (Fergus & Zimmerman, 2005). Enhancing external resources can be a focus of change to help adolescents with high risk factors prevent negative outcomes (Fergus & Zimmerman, 2005).

A variety of protective factor measures have been reported in the literature that has researched the development of resiliency for children and adolescents exposed to risk factors for physical aggression. Individual-level protective factors have been measured in constructs such as: emotion control (Cooley & Fite, 2016; Sullivan et al., 2010) and coping skills (Polan et al.,
Family-level protective factor measures include parental attachment (Kapoor & Tung, 2017; Murphy et al., 2017; Resnick et al., 2004; Smokowski et al., 2017; Taylor et al., 2016) and family connectedness (Dubow et al., 2016; Frey, Ruchkin, Martin, & Schwab-Stone, 2009; Herrenkohl et al., 2003; Jia et al., 2016; Kramer-Kuhn & Farrell, 2016; Resnick et al., 1997; Resnick et al., 2004; Shlafer et al., 2013; Taylor et al., 2016). School-level protective factors include school attendance (Rocque et al., 2017) and school engagement (Batanova & Loukas, 2014; Bernat et al., 2012; Duggins et al., 2016; Fontaine et al., 2016; Frey et al., 2009; Herrenkohl et al., 2003; Simons-Morton et al., 2004; Smokowski et al., 2017; Voisin & Elsaesser, 2016).

**Protective Factors that Mediate or Moderate the Association Between Overweight/Obesity and Aggression in Children and Adolescents**

In the sections that follow the discussion of resiliency assets and resources presented above are applied to research that has examined the association between overweight/obesity and physical aggression. While many studies have reported significant associations between overweight/obesity and aggression, the central focus appears to be on risk factors that mediate the relationship. It is clear, however, that not all overweight/obese children and adolescents become aggressive, which suggests the presence of protective factors that may moderate the negative effects of overweight/obesity on developmental trajectories. In what follows, studies are summarised that have investigated individual-level, family-level, and school-level factors that may have protective effects against both overweight/obesity and aggression in children and adolescents.

**Individual-Level Factor: Emotion Control**
Learning to manage emotional expression in childhood and adolescence is regarded as a major developmental milestone, as adaptive emotion regulation has been found to be critical to healthy psychological and social functioning (Cole & Hall, 2008; Cole, Michel, & Teti, 1994). Emotion control (also known as emotion regulation) refers to the internal and external processes an individual utilises in an attempt to not only understand and monitor affective states, but to adjust the intensity and duration of emotional reactions to stimuli (Thompson, 1994). This self-regulation of emotions also involves efforts (which may be conscious or unconscious) to alter or transform inner states or responses to stressful situations in order to maintain a positive affective or physical health status or to improve or suppress a negative affective status (Compas et al., 2014; Gross, 2013). Emotion control can also involve the development of coping mechanisms in order to assist with managing stressful situations to avoid them overwhelming emotions (Campos, Frankel, & Camras, 2004; Eisenberg & Spinrad, 2004). Thus, effective and adaptive emotion regulation involves utilisation of strategies, such as behavioural distraction, focusing on the positive, problem-solving, and seeking out social support. These strategies are used in attempts to contain emotional arousal in order to avoid undesired consequences of stress and to prevent the negative emotions from overwhelming and impairing one’s ability to function normally and to avoid engaging in maladaptive behaviours (Cole et al., 1994).

The acquisition of adaptive strategies to regulate emotions is of extensive relevance for social functioning (Eisenberg et al., 2000; Saarni, 1999). Accordingly, studies demonstrate that children and adolescents with better emotion regulation strategies have a higher peer status, better relationship quality and engage in more pro-social behaviour (Eisenberg et al., 2000; Southam-Gerow & Kendall, 2002). Conversely, emotion dysregulation is linked to persistence of psychopathology (Zeman, Shipman, & Suveg, 2002). Common characteristics of poor
emotion regulation (or emotion dysregulation), that have been linked to psychopathology symptoms (Röll, Koglin, & Petermann, 2012) involve the use of maladaptive cognitive coping strategies, such as rumination, catastrophic thinking, as well as ineffective behavioural responses, including aggressive action and social withdrawal (Kelly et al., 2016).

Associations have been found between emotion control and both overweight/obesity (Graziano et al., 2010; Kelly et al., 2016; Power et al., 2016; Tsukayama et al., 2010) and aggression in childhood/adolescence (Cooley & Fite, 2016; Sullivan et al., 2010). Higher levels of emotion control appear to have a protective effect against both of these outcomes, as emotion regulation appears to play an important role in the development of aggression. Research evidence suggests that anger, more so than any other emotion, commonly precedes aggressive action and individuals who have difficulty regulating feelings of anger are more likely to exhibit aggressive behaviours (Cooley & Fite, 2016). As such, youth who are able to more effectively regulate feelings of anger that may accompany negative and frustrating experiences in adolescence may be better equipped to navigate conflict in a peaceful manner, and less likely to respond with aggression (Cooley & Fite, 2016). Conversely, difficulties with emotion control may inhibit a young person’s ability to process social information and generate effective problem-solving responses, thereby increasing the likelihood of reacting aggressively in situations involving conflict (Cooley & Fite, 2016).

**Individual-Level Factor: Coping Skills**

Closely linked to emotion control and regulation, coping refers to adaptive efforts to respond to stress (Folkman & Moskowitz, 2004). Coping skills refer to the behavioural and cognitive strategies that are engaged when attempting to overcome, tolerate or minimise the impact of a stressful or threatening event (Carver & Scheier, 1994). Coping includes behavioural, cognitive,
affective and social strategies. The broad construct of coping includes emotion control strategies to influence and adjust the occurrence, intensity, or duration of negative internal states and emotion-related physiological processes in an adaptive way (Eisenberg et al., 2000; Southam-Gerow & Kendall, 2002). Researchers have suggested that children who possess poor emotional control are more likely to engage in ineffective and maladaptive coping responses in the face of stressful situations (Kochenderfer-Ladd, 2004; Toblin, Schwartz, Hopmeyer Gorman, & Abouezzeddine, 2005) such as avoidance and withdrawal, aggression, or high levels of emotional expression (crying, and other behavioural exhibitions of emotional distress) (Eisenberg, Fabes, & Guthrie, 1997; Rubin, Coplan, Fox, & Calkins, 1995).

Utilisation of maladaptive coping strategies have been linked to both overweight/obesity (Boggiano et al., 2015; Jääskeläinen et al., 2014) and aggression (Polan et al., 2013; Sullivan et al., 2010) in children and adolescents. Some researchers have hypothesised and received support for the idea that some youth may eat excess food (thereby leading to overweight/obesity) in an attempt to enhance reward and to cope with stress (Graziano et al., 2010; Rollins, Loken, Savage, & Birch, 2014). It may also be possible that children and adolescents may not understand the concept of using food to cope or may not be aware that this is what they are doing until such time that they are older, have acquired greater cognitive capacity, and are able to develop more adaptive coping strategies (Boggiano et al., 2015). Adolescents with poor coping skills have a higher tendency to respond to stressful situations with aggressive behaviour (Whitman & Gottdiener, 2015).

**Family-Level Factor: Parental Attachment**

Parental attachment refers to the strong and continuous positive feelings felt by an individual towards parents or caregivers. Attachment theory maintains that early social experiences and
interactions are crucial to the healthy development of a child. Early social experiences establish
the foundation through which social interactions (including those with family members and
others) are understood in later life (Bowlby, 1982). Attachment theorists have long stressed the
importance of the parent-child bond for the development of children’s social competence.
Children with secure parental attachments (as opposed to insecure attachments) tend to be more
socially competent and prosocial, more accepted by their peers, have better quality relationships
with their parents and peers, and display more sophisticated emotional development including
better regulation of emotions (Berlin, Cassidy, & Appleyard, 2008; Gomez & McLaren, 2007;
Grossmann, Grossmann, & Waters, 2006; Morris, Silk, Steinberg, Myers, & Robinson, 2007;
Sroufe, 2005; You & Kim, 2016). Indeed, research literature supports the notion that children
who are securely attached to caregivers and who receive support, comfort, and love, develop
positive internal working models of themselves. Children with secure attachments are more
likely to view others as trustworthy and dependable, and interact with higher levels of warmth
and affection (Bowlby, 1982; Bretherton & Munholland, 2008; Thompson, 2008). Conversely,
children with insecure attachment to parental figures, construct internal working models of the
self and others as untrustworthy, threatening, unreliable. This leads consequently to responding
to others in a more rejecting or ambivalent way, with those relationships often characterized by
anger, distrust, chaos, and insecurity (Bowlby, 1982). Recent empirical studies provided further
support for this notion, showing that early insecure attachment relationships are associated with
poor social skills, externalizing behaviour problems, severe antisocial behaviour, childhood
aggression, conduct disorder, and delinquency (Allen, Hauser, & Borman-Spurrell, 1996; Allen
et al., 2002; Fagot & Kavanagh, 1990; Greenberg, Speltz, & DeKlyen, 1993; Lyons-Ruth, 1996;
In late childhood and early adolescence, attachment to parents takes on a different form, and changes from expectations of being given physical comfort and care to the belief and trust that parents and others will support the individual when needed in their interactions with the wider world (You & Kim, 2016). At this stage of development, positive relationships with parents, characterised by high levels of support, trust, open communication, and care are especially important as the socio-emotional changes of the adolescent period are navigated. Children and adolescents often look to their parents for guidance, including how to understand, regulate and cope with stressful life events (Kapoor & Tung, 2017). In the late periods of adolescence, when social rules and values have already been acquired and internalised, the quality of the perceived parental bond continues being important (Gallarin & Alonso-Arbiol, 2012). Since the perception of security in affective bonding with others arises from the security in attachment to parents, these relationships continue being the most important model for future relationships (Berlin et al., 2008). Indeed, Gallarin and Alonso-Arbiol (2012) found in their study that although individuation/identity formation processes are important in adolescence, parents continue being a clear source of protection and support (Allen, 2008).

Where parents are positive role models, it appears that strong and secure parental attachment may have a protective effect against both overweight/obesity (Hooper et al., 2014; Keitel-Korndörfer et al., 2015; Maras et al., 2016) and aggression (Kapoor & Tung, 2017; Murphy et al., 2017; Resnick et al., 2004; Smokowski et al., 2017; Taylor et al., 2016) in children and adolescents. The presence of strong parental support and bonding may increase the likelihood that antisocial behaviour would be detected and discouraged. Supportive parents are invested in their children’s development and are more likely to encourage them to: connect with pro-social peers and adults, engage in pro-social activities, and discourage association with unacceptable
peers, and reinforce pro-social parental expectations (Smokowski et al., 2017). Arım et al. (2011) found that parent and child bonding increased as a result of parental support and, over time, was associated with decreased aggression. Parental attachment has continued to emerge as a potentially important protective factor for aggressive behaviour as it appears that a strong sense of connectedness with parents also assists young people to manage stressful experiences without recourse to aggressive behaviour (Duggins et al., 2016).

**Family-Level Factor: Positive Family Interactions (Family Connectedness)**

The most influential protective social interactions are those that occur regularly, over an extended period of time, and between people with a strong and mutual bond (Bronfenbrenner & Morris, 1998). Although interactions within the family may occur less frequently during adolescence, they tend to remain influential throughout adolescence (Collins & Roisman, 2006; Larson, Moneta, Holmbeck, & Duckett, 1996). Positive family interactions teach the adolescent how to socially interact successfully by providing the opportunity to gain pro-social knowledge, skills, and beliefs that prevent negative youth development outcomes (Collins & Roisman, 2006; Sameroff, 2006).

Family connectedness refers in what follows to healthy family environment characteristics that include pro-social bonding, climate and family resources. Studies demonstrate that higher levels of family connectedness and cohesion yield protective effects for both overweight/obesity (Halliday et al., 2014; Hooper et al., 2014) and aggression (Dubow et al., 2016; Frey et al., 2009; Herrenkohl et al., 2003; Jia et al., 2016; Kramer-Kuhn & Farrell, 2016; Resnick et al., 1997; Resnick et al., 2004; Shlafer et al., 2013; Taylor et al., 2016) in children and adolescents. Kitzman-Ulrich et al. (2010) proposed that families experiencing stress often have limited access to resources that might otherwise promote a healthy lifestyle, such as a safe neighbourhood to
exercise in, or finances to purchase and store healthy foods. Likewise, families with unhealthy social-emotional climates (for example, high conflict and low support) disrupt healthy behaviours and induce physiological stress responses, which can lead to unhealthy behaviours and weight gain (Kitzman-Ulrich et al., 2010). Similarly, Ebbeling, Pawlak, and Ludwig (2002) found that adolescents who are embedded in a supportive family environment will be more likely to experience and engage in healthy family-related exercise and eating behaviour, whereas children in less supportive environments (for example where parents are neglectful or unavailable) are more likely to experience obesity during childhood and are less likely to engage in family-related exercise and eating behaviour (Hooper et al., 2014).

Positive family interactions are associated with lower adolescent physical aggression. Family factors such as support, structure, cooperation, and communication are associated with lower levels of adolescent aggression and other externalising problems (Gomez et al., 2001; Heidgerken et al., 2004; Kliwer et al., 2004; Kliwer et al., 2006). A well-functioning family can provide young people with the emotional resources needed to process daily stressors, to develop more empathy or perspective taking, which could buffer them from negative social contexts (Andreas & Watson, 2009; Kliwer et al., 2006). Positive family environments may also provide examples of prosocial behaviours and constructs within social interactions, as family conversations can provide important opportunities for parents to guide their adolescents’ values and potential responses to peer problems (Werner & Grant, 2009). Through direct communication of their beliefs, parents can help adolescents understand and constructively approach conflicts using nonviolent strategies (Garbarino, Kostelny, & Dubrow, 1991).

**School-Level Factor: School Attendance**
There is support in the research literature for associations between school attendance and lower levels of overweight/obesity (Bethell et al., 2010; Carey et al., 2015; Echeverría et al., 2014; Richmond et al., 2014; Tsukayama et al., 2010) and aggression (Rocque et al., 2017) in children and adolescents. Most of the research literature in this area appears to centre around overweight/obesity leading to non-attendance at school. This may be a result of experiencing higher levels of bullying or teasing at school (Janssen et al., 2004), being embarrassed to participate in physical activities at school (Taras & Potts-Datema, 2005), or result from overweight/obesity-related health conditions leading to time off school (Baxter et al., 2011; Echeverría et al., 2014). In adults, the association between chronic medical conditions associated with overweight/obesity (such as diabetes, pulmonary and cardiovascular disease, and musculoskeletal disorders) is well established and likely contributes to the observed relationship between obesity and absence from employment (Ostbye, Dement, & Krause, 2007). Medical comorbidities associated with obesity are less prevalent in children than in adults but do increase with the degree of obesity (Weiss et al., 2004; Xanthakos & Inge, 2007).

School absences also appear to be associated with delinquent behaviour, with inadequate school attendance often a gateway into future serious antisocial behaviours (Wang, Blomberg, & Li, 2005). For example, Dalun et al. (2010) found that truants were more likely to be referred to the juvenile justice system at an earlier age, and had more incidences of incarceration and more probation stints than other offenders. This may be because school absenteeism results in young people missing out on the positive benefits not only of education (Rocque et al., 2017) but of socialisation opportunities with prosocial peers and teachers, which may protect against youth aggression trajectories (Simons-Morton et al., 2004).

**School-Level Factor: School Engagement**
School engagement captures mostly affective and cognitive aspects of students’ school experiences and includes students’ sense of safety, belonging to the school, and perceptions of teachers’ fairness and support (Resnick et al., 1997). It has been found to be related to both overweight/obesity (Carey et al., 2015; Richmond et al., 2014) and aggression (Batanova & Loukas, 2014; Bernat et al., 2012; Diggins et al., 2016; Fontaine et al., 2016; Frey et al., 2009; Herrenkohl et al., 2003; Simons-Morton et al., 2004; Smokowski et al., 2017; Voisin & Elsaesser, 2016) in children and adolescents. Several explanations may account for overweight/obese children and adolescents experiencing lower levels of school engagement. As previously discussed, overweight/obese children and adolescents experience higher rates of school absenteeism, which would impact on school engagement. Richmond et al. (2014) explain that health promotion messages (such as healthy eating and regular exercise) tend to be more effectively transmitted in socially cohesive schools. A climate of safety and mutual respect within an educational environment reduces stress and thereby promotes the mental well-being of students. Parental involvement in the child’s school is often greater when children are engaged, and has been linked to more effective action in the promotion of the health and wellbeing of children (Richmond et al., 2014). Additionally, social contexts (including that of the school and family), provide exposure to pro-social peers and other pro-social adults, that are protective influences that prevent aggression (Simons-Morton et al., 2004).

Youths who have difficulty adjusting to secondary school and fail to become engaged may be more likely to develop antisocial attitudes, to affiliate with problem-behaving friends, and to engage in aggressive and other antisocial behaviour (Erdley & Asher, 1998; Paetsch & Bertrand, 1997; Simons-Morton et al., 2004; Snyder, Dishion, & Patterson, 1986). Youth who adjust well to school may be less likely to affiliate with problem-behaving youth or less influenced by this
association (Simons-Morton et al., 2004). Batanova and Loukas (2014) found that perceived levels of school connectedness uniquely contributed to a decrease in overt aggression, suggesting that feelings of school belonging and closeness with teachers and peers might be especially important for reducing overt aggression. Specifically, feeling accepted and supported by people at school might discourage young people from displaying overtly aggressive behaviours (Crosnoe, Erickson, & Dornbusch, 2002).

Schools also have the potential to assist communities with building a common set of values and norms, thus promoting an increasingly stable pro-social environment. In the schools, both teachers and administrators can play an integral part in the development of resiliency in youth exposed to multiple risks. Schools help students develop resiliency by providing positive and safe learning environments, setting high, yet achievable, academic and social expectations, and facilitating their academic and social success. Also, youth who belong to a socially appropriate group sponsored and supported by the school (e.g., academic club or social organisation) are less likely to demonstrate aggression. Positive adult role models outside of the family can be instrumental in teaching a child strategies for avoiding trouble and interacting positively with others (Mann & Yadav, 2016).

Conclusion

To the authors’ knowledge, no study has yet examined potential protective factors across a range of domains within the individual level and also within the family and school levels that could mediate or moderate the effects of overweight/obesity on physical aggression. In addition, scant research has examined protective factors within analyses integrating measures of multiple risk factors in studies examining the association between overweight/obesity (as indexed by body mass index (BMI)) and physical aggression in childhood or adolescence. The analyses to be
presented in the next section of the present thesis aim to contribute to these research gaps. This chapter reviewed research examining protective factors that arise in resiliency theories and their application to the study of overweight/obesity and physical aggression. The chapter that follows presents an empirical investigation of these issues in a large Australian sample of children and adolescents.
Chapter 7: Article 3: An empirical investigation of protective factors to reduce the association between overweight/obesity and physical aggression in adolescents

Submitted for publication to Journal of Research on Adolescence

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Conducted the literature search, contributed to the conception of the study and the planning of the analysis, contributed to statistical analysis, contributed to data interpretation and drafted the full manuscript and incorporated the revisions of the other 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>
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| **Belinda L. Guadagno**  
Deakin University, Melbourne, Victoria, Australia | Contributed to planning; redrafting and critical revision of the manuscript |
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The data was obtained by the executive author in de-identified STATA data files. The original data comes from the Healthy Neighbourhoods Project. The Healthy Neighbourhoods custodian for this project is Professor John Toumbourou from Deakin University.

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Abstract

Overweight or obese adolescents are more likely to engage in physically aggressive behavior. The current study estimated the extent to which this association was modified by protective factors. Data from a nationally representative sample of Australian adolescents aged 10-14 years was utilized (N = 7,288). Based on multi-variate modeling, emotion control and school attendance partially mediated the association between overweight/obesity and physical aggression in children and adolescents, while mid-levels of coping skills, parental attachment, and school engagement moderated the relationship. Interaction effects between coping skills and BMI, and school engagement and BMI were significantly associated with physical aggression. Protective factors reduced but did not eliminate the association. BMI maintained a significant association with physical aggression (IRR = 1.009, 95% Confidence Interval 1.004 - 1.015, p = .001) after controlling for demographic variables, shared risk factors, and protective factors. The implications of these findings for the developmental processes that may explain the association between adolescent overweight/obesity and physical aggression are discussed.

Key words: Adolescence; obesity; aggression; risk factors; protective factors; adolescent development
Introduction

Overweight and obesity are defined as a body mass index (BMI) above current health guideline criteria (Cole et al., 2000). Physical aggression is distinct from other types of aggression (such as verbal or cyber aggression), and specifically refers to physical contact intended to harm another (Barker et al., 2007). Overweight/obesity and engaging in physical aggression are both highly prevalent problems that affect adolescents internationally. A recent systematic review and meta-analysis revealed that adolescent overweight/obesity and physical aggression are consistently associated with an average effect size of 0.27 (95%CI: .17-.37) (Tso et al., 2017). The current paper estimated within a large Australian dataset the extent to which this association arises from common risk factors and is potentially modifiable through protective factors.

Overweight/obesity in childhood and adolescence affects approximately 25% of young people in Australia (National Health and Medical Research Council, 2013; 2014; Australian Bureau of Statistics, 2013) and in the United States (Centers for Disease Control and Prevention, 2014). Large-scale, nationally representative studies in Australia and the United States indicate that up to 33% of adolescents had engaged in some form of violent behavior in the previous twelve months (Bond et al., 2000; Eaton et al., 2012; Vassallo et al., 2002; Williams et al., 2009).

Overweight, obesity and aggression are priority adolescent health and social problems. Adolescents experience greater future health problems when they are overweight/obese (National Health and Medical Research Council, 2013) and exhibit more frequent physically aggressive behaviors. Physically aggressive behavior can lead to long-term participation in criminal activity and consequences within the justice system (Fergusson & Woodward, 2000; Samuelson et al., 2010).
Evolutionary and Social Dominance theories have offered explanations for the effect of overweight/obesity on youth physical aggression. The basic premise of these theories is that overweight/obese individuals are more likely to engage in acts of physical aggression because they are generally bigger in stature and more able to overpower smaller peers, and that acts of physical aggression occur because they are functional and offer advantages in competition with rivals (Brooks-Gunn & Furstenberg, 1989; Kolbert & Crothers, 2003). These competitive advantages may in-turn increase access to resources such as nutrition and defend against predators (Kolbert & Crothers, 2003). From a more modern perspective, this may equate to greater influence over others within the peer group, and greater appeal to both peers and potential sexual partners (Closson, 2009; Hawley, 1999; Savin-Williams, 1979).

The association between adolescent overweight/obesity and physical aggression may also partly arise due to common developmental characteristics. A number of common risk factors that predict an increased future likelihood of disorders have been identified for both adolescent overweight/obesity and aggression.

Both overweight/obesity and aggression are known to vary across demographic factors including age, gender and socio-economic status (SES) (Galan et al., 2017; Wu et al., 2015). Common risk factors for both overweight/obesity and aggression have been identified at the individual and peer levels. At the individual level, common factors include impulsivity (Hatfield & Dula, 2014; Lanza et al., 2014), substance use (including alcohol (Battista & Leatherdale, 2017; Valdebenito et al., 2015)), tobacco (Huang et al., 2013; Lanza et al., 2014), and other drug use (Clark et al., 2008; Zeller et al., 2016), depressive symptoms (Priddis et al., 2014; Wilson & Sato, 2014), unhealthy food consumption (such as excess junk food and sugar) (Shang et al., 2014; Solnick & Hemenway, 2011), and computer use/video game play (Kelishadi et al., 2015;
Strasburger et al., 2010). Common risk factors have also been identified in peer relationship problems (Jansen et al., 2014; van Geel et al., 2014). In a previous study we identified that the effect of overweight/obesity on adolescent physical aggression was maintained after controlling for common risk factors (Tso et al., 2017).

Given a number of common risk factors lie in childhood, researchers have attempted to identify adolescent protective factors that may enhance resiliency by promoting positive adaptation despite the presence of risk factors (Garmezy, 1990; Luthar & Zigler, 1991; Masten et al., 2008; Rutter, 1990; Werner & Smith, 1992). Protective factors have been identified at the individual, family and school levels. At the individual level these include emotion control (Cooley & Fite, 2016; Kelly et al., 2016) and coping skills (Boggiano et al., 2015; Whitman & Gottdiener, 2015). At the family level they include parental attachment (Kapoor & Tung, 2017; Keitel-Korndörfer et al., 2015) and positive family interactions (or family connectedness) (Andreas & Watson, 2009; Hooper et al., 2014). At the school level, protective factors include school attendance (Dalun et al., 2010; Richmond et al., 2014) and school engagement (Batanova & Loukas, 2014; Richmond et al., 2014).

The current study utilized data from a large (N = 7,288) representative sample of Australian primary and secondary school children. Measured height and weight and valid adolescent self-report measures of aggression and common risk factors were available, in addition to protective factors. A previous analysis using the current sample had identified that the effect of adolescent body weight (indicated by age and gender adjusted effects on specific body mass index: BMI) on aggression was maintained after controlling for common risk factors (Tso et al., 2017). The present study aimed to investigate whether the effect of BMI on aggression would be reduced by the protective factors of emotional control, coping skills, school attendance, school engagement,
parental attachment and family connectedness. We hypothesized that after controlling for the shared risk and protective factors, the association between overweight/obesity and physical aggression would remain significant; however, the shared protective factors would mediate or moderate the effect of BMI on physical aggression and the strength of the association would be reduced.

**Methods**

**Sample and Study Design**

Data used in this study were collected through the Healthy Neighbourhoods Project, a cross-sectional survey examining the health and wellbeing of students from 30 communities across three states in Australia: Victoria, Queensland, and Western Australia in 2006. The measures were based on the Communities That Care Youth Survey, an epidemiological assessment instrument that was developed in the United States (Arthur et al., 2002), and adapted for Australian youth populations (Beyers et al., 2004; Hemphill et al., 2010). The Australian survey scales demonstrate similar reliability to US populations, with Cronbach’s alpha (α) coefficients for multi-item scales generally above .70 (Kelly et al., 2011).

Across the 30 communities, school surveys were conducted with grade six and grade eight students. The ages of the participants ranged between 10-16 years. The schools invited to participate comprised government, independent, and Catholic schools. A total of 231 schools participated (61% government, 22% independent, and 17% Catholic). The community sampling frame consisted of Statistical Local Areas (SLA’s; an Australian Standard Geographic Classification structure consisting of non-overlapping spatial units (Australian Bureau of Statistics, 2006) with greater than 17,000 inhabitants. These SLAs were stratified into quartiles of socioeconomic disadvantage based on Socio-Economic Indexes for Areas (SEIFA). Eligible
communities were randomly selected from SEIFA quartiles to represent national distributions in advantage/disadvantage and urban and non-urban locations. Quartile 1 represented the most disadvantaged areas, and quartile 4 identified the most advantaged.

A random selection of schools in the selected areas were invited to participate in the survey, and the final sample included eight communities in each of Queensland and Western Australia, and 14 communities in Victoria. Across the 30 communities, 8,256 of the eligible students consented and participated in the survey, representing approximately 54% of the initially approached students. Standard data collection protocols were followed in each state, approved by the University of Melbourne’s Human Research Ethics Committee (Vic), the Griffiths University Human Research Ethics Committee (QLD), and the Curtin University of Technology Human Research Ethics Committee (WA). Approvals were also obtained from the relevant governing school authorities in each state. Students participated only if they assented and signed parental consent was given. The survey was web-based and completed during school class time during a 45-60 minute period, and paper copies of the survey were provided if computer resources were not available. Basic physical health measurements of height and weight were also taken by trained researchers (Williams et al., 2015).

As a check on the reliability of responses, a question was included about the use of a fictitious drug and another question was included asking each participant how honest they were in filling out the survey. Participants who reported using the fictitious drug or dishonesty were excluded from the analyses (n = 151). A further 817 participants were excluded because of missing data on one or more key variables. The final analysis data set consisted of 7,288 children aged 10-14 years (mean = 11.58 years, SD = 0.81).

Measures

Dependent variable.
**Aggression.** The dependent variable was an ordinal count variable created to identify the number of occasions that participants reported having engaged in physically aggressive behavior in the last 12 months. This variable consisted of the average of responses from two items on the survey which asked how many times in the past year they had: ‘attacked someone with the idea of seriously hurting them’, or ‘beat up somebody so badly that they probably needed to see a doctor or nurse’ (α = 0.64). Response options were provided on a 5-point scale, including ‘never’ (0), ‘1 or 2 times’ (1), ‘3 to 5 times’ (2), ‘6 to 9 times’ (3), and ’10 or more times’ (4).

**Independent variable.**

**Body Mass Index (BMI).** Participants’ heights and weights were measured by trained research staff with standardized equipment and procedures. Body mass index was calculated by utilizing the following formula: weight (in kilograms)/height (in meters)$^2$.

**Risk Factors measures**

**Impulsivity.** Three items: ‘It is important to think before you act’, ‘I rush into things, starting before I know what to do’, and ‘I answer without thinking about it first’. Response options were: ‘YES!’ , ‘yes’, ‘no’, and ‘NO!’.

**Alcohol/tobacco/other drug use.** Respondents were asked if, in their lifetime, they had ever: smoked cigarettes; had more than just a few sips of an alcoholic beverage; used marijuana; sniffed glue, breathed the contents of an aerosol spray can, or inhaled other gases or sprays, in order to get high; used other illegal drugs (like cocaine, heroin, ecstasy, or amphetamines/speed); used stimulants (speed, amphetamines, uppers, meth, crystal, crank); used ecstasy (XYC, E, X, MDMA, eccies, dove); used heroin (bomb, H, smack, junk); or used other illegal drugs. Response options ranged from ‘Never’ to ‘10 or more times’.

**Depressive symptoms.** The Short Mood and Feelings Questionnaire (SMFQ) (Angold et al., 1995) was incorporated into this survey, comprising 13 questions about negative mood,
feelings and behaviours in the past 2 weeks. Participants could answer questions as either ‘True’ (=2), ‘Sometimes true’ (=1) or ‘Not true’ (=0). Scores on the 13 questions were summed for each participant, and total SMFQ scores ranged from 0 (indicating complete absence of depressive symptomatology) to 26.

**Unhealthy food consumption.** This was measured with items asking participants how many serves of the following foods were eaten per day: hamburgers, hot dogs, sausages, potato crisps/savoury snacks, biscuits, donuts, cake, pie, chocolate, sweet drinks (such as soft drinks, cordial, Big M, flavoured mineral water, etc.), with six response options ranging from ‘None’ to ‘5 or more’, as well as how often they usually ate food from a takeaway/fast food outlet (such as McDonalds, KFC, Hungry Jacks, Subway, fish and chips, hamburgers, etc.), with six responses ranging from ‘Less than once a month’ to ‘Most days’.

**Peer victimisation/rejection.** This was measured by asking participants whether they had ‘been bullied recently (teased or called names, had rumours spread [about them], been deliberately left out of things, threatened physically, or actually hurt’. Responses were measured on a four-point scale from ‘No’ to ‘Yes most days’.

**Computer use/video game play.** This was measured by hours per day spent on a computer or playing video games such as Gamecube, xBox, PS2, PSP, GBA, etc. on school days and weekend days. Response options ranged from ‘None’ to ‘more than 6 hours’.

**Protective Factor measures.**

**Emotion control.** 4-items: ‘I know how to relax when I feel tense’, ‘I am always able to keep my feelings under control’, ‘I know how to calm down if I am feeling nervous’, and ‘I control my temper when people are angry with me’ (α = 0.74). Response options for these items and those below were: ‘YES!’ (4) to ‘NO!’ (1).
**Coping skills.** 4-items: ‘When I have a problem, I blame myself’, ‘I criticise myself or lecture myself’, ‘I think about the best ways to handle the problem’, and ‘I am good at working it out’ ($\alpha = 0.59$).

**Parental attachment.** 4-items: ‘Do you feel close to your mother?’, ‘Do you share your thoughts and feelings with your mother?’, ‘Do you feel close to your father?’, and ‘Do you share your thoughts and feelings with your father?’ ($\alpha = 0.77$).

**Family connectedness.** 7-items: ‘My parents notice when I am doing a good job and let me know about it’, ‘How often do your parents tell you they’re proud of you for something you’ve done?’, ‘Do you enjoy spending time with your mother?’, ‘Do you enjoy spending time with your father?’, ‘If I had a personal problem, I would ask my mum and dad for help’, ‘My parents give me lots of chances to do fun things with them’, and ‘My parents ask me what I think before most family decisions affecting me are made’ ($\alpha = 0.82$).

**School attendance.** 1-item: ‘During the last 4 weeks, when school was in session, how many whole days have you missed because you skipped or wagged?’. Response options ‘None’ (4) to ’11 or more’ (1)

**School engagement.** 4-items: ‘My teachers notice when I am doing a good job and let me know about it’, ‘I feel safe at my school’, ‘The school lets my parents know when I have done something well’, and ‘My teachers praise me (tell me I’m doing well) when I work hard in school’ ($\alpha = 0.80$). Response options for these items and those below: ‘YES!’ (4) to ‘NO!’ (1).

**Control variables.** To adjust for confounding effects, demographic controls included gender, age, and Socioeconomic Status (SES) (measured by SEIFA disadvantage quartile).

**Analysis**
All data analyses were performed using Stata/MP 14.0 statistical software (StataCorp, 2015). As the dependent variable of aggression was a count indicator with a highly skewed distribution, a modified Poisson regression analysis (negative binomial regression that fits a Poisson distributed outcome with robust standard errors (Zou, 2004)) was used to model incident rate ratios (IRRs). Model 0 predicted aggression from BMI, with control of covariates for age, gender, and SES.

Mediation and moderation analyses were conducted for each of the protective factors. To investigate moderation, each of the protective factors was divided by four quartile levels and the Model 0 analysis was run separately at each level. Initial criteria for moderation required the 95% confidence intervals to be clearly separated for the incident rate ratio (IRR) effect of BMI on aggression across different levels. Where the confidence intervals for the IRR effect varied across levels, interaction terms were developed to compare the effect of BMI at two different levels of the predictor. Variables that satisfied the initial moderation criteria by showing a significant BMI interaction effect in Model 0 were entered as interaction terms in the final multivariate analyses (Models 1 and 2 described below).

To be included as a potential mediator significant associations had to be evident between BMI, the mediator and aggression and the effect of BMI on aggression had to be significantly reduced when the mediator was entered into regression Model 0 (see Kenny, Kashy, and Bolger (1998)). Wald tests were used in Stata to test whether the effect of BMI was significantly reduced with the entry of the mediator into Model 0. Those factors that demonstrated mediation or moderation effects in regression Model 0 analyses were added to the final multivariate models.
Regression Model 1 (see Table 3) was multivariate adjusted for all risk factors and all protective factors and their relevant interactions with BMI (moderation variables identified as described above). Regression Model 2 was multivariate adjusted for all Model 1 predictors, but in addition included mediational predictors (identified as described above).

The data were of a clustered nature (individual schools clustered within Statistical Local Areas) and there was small but significant school clustering of aggression, hence, adjustments for clustering were incorporated into analyses using the STATA ‘svy’ command.

**Results**

Table 1 presents Pearson correlations between aggression, BMI, demographic variables, and protective factors. Table 1 demonstrates that all predictor variables were significantly related to aggression in the expected direction, where higher levels of emotion control ($r = -0.143, p < .001$), coping skills ($r = -0.129, p < .001$), parental attachment ($r = -0.066, p < .001$), family connectedness ($r = -0.105, p < .001$), school attendance ($r = -106, p < .001$), and school engagement ($r = -0.120, p < .001$) were associated with lower levels of aggression. Of the demographic variables, female gender ($r = -0.146, p < .001$) and higher SEIFA SES advantage quartile ($r = -0.027, p < .05$) were protective against aggression; however, age was not ($r = 0.023, p = .05$).

The results of the moderation and mediation analyses are presented in Table 2. The moderation analyses revealed three factors that satisfied initial criteria in showing significant interactions with BMI. The effect of BMI on aggression was significantly reduced for mid relative to low or high-levels of coping skills ($\text{IRR} = 0.99, p = .01$), parental attachment ($\text{IRR} = 0.99, p = .01$) and school engagement ($\text{IRR} = 0.99, p = .02$). There were two variables that satisfied the mediation criteria: emotional control and school attendance. Table 1 reveals that
each of these variables were significantly correlated with BMI and aggression. Table 2 presents the results of the Wald test and shows that when each of these variables were entered into Model 0 there was a significant reduction in the effect of BMI on aggression. As family connectedness did not satisfy criteria for either moderation or mediation, it was removed from further analyses.
Table 1. Pearson correlations between aggression, BMI, demographic variables, and protective factor covariates (N = 7,288).

<table>
<thead>
<tr>
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<th>1</th>
<th>2</th>
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<th>8</th>
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<th>10</th>
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<tbody>
<tr>
<td>2</td>
<td>0.047</td>
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<tr>
<td>4</td>
<td>0.023</td>
<td>0.170</td>
<td>-0.077</td>
<td></td>
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<tr>
<td>5</td>
<td>-0.027</td>
<td>-0.086</td>
<td>-0.035</td>
<td>-0.005</td>
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<tr>
<td>6</td>
<td>-0.143</td>
<td>-0.044</td>
<td>0.035</td>
<td>-0.089</td>
<td>0.005</td>
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<tr>
<td>7</td>
<td>-0.129</td>
<td>-0.036</td>
<td>0.005</td>
<td>-0.075</td>
<td>-0.010</td>
<td>0.438</td>
<td></td>
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<tr>
<td>8</td>
<td>-0.066</td>
<td>-0.060</td>
<td>-0.052</td>
<td>-0.187</td>
<td>0.035</td>
<td>0.246</td>
<td>0.258</td>
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<tr>
<td>9</td>
<td>-0.105</td>
<td>-0.067</td>
<td>0.017</td>
<td>-0.169</td>
<td><strong>0.029</strong></td>
<td>0.292</td>
<td>0.310</td>
<td>0.721</td>
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<tr>
<td>10</td>
<td>-0.106</td>
<td>-0.065</td>
<td><strong>0.028</strong></td>
<td><strong>0.024</strong></td>
<td>0.060</td>
<td>0.045</td>
<td>0.050</td>
<td><strong>0.030</strong></td>
<td><strong>0.037</strong></td>
<td></td>
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<tr>
<td>11</td>
<td>-0.120</td>
<td>-0.046</td>
<td>0.073</td>
<td>-0.186</td>
<td>-0.022</td>
<td>0.278</td>
<td>0.255</td>
<td>0.299</td>
<td>0.387</td>
<td>0.035</td>
</tr>
</tbody>
</table>

*Key: (1) Aggression, (2) BMI, (3) Gender (Sex), (4) Age, (5) SEIFA Advantage Quartile, (6) Emotion control, (7) Coping skills, (8) Parental attachment, (9) Family connectedness, (10) School attendance, (11) School engagement

**Bold figures indicate significant effects of p < .05, and underlined figures indicate significant effects of p < .01**
Table 2. Moderation and mediation analyses for effects of BMI predicting aggression in children and adolescents (N = 7,288).

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Prevalence (%)</th>
<th>Moderation effect</th>
<th>Mediation effect</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>IRR</td>
<td>95% CI</td>
</tr>
<tr>
<td>Emotional Control</td>
<td>78</td>
<td>0.99</td>
<td>0.99-1.00</td>
</tr>
<tr>
<td>Coping skills&lt;sup&gt;m&lt;/sup&gt;</td>
<td>52</td>
<td>0.99</td>
<td>0.99-1.00</td>
</tr>
<tr>
<td>Family connectedness&lt;sup&gt;m&lt;/sup&gt;</td>
<td>53</td>
<td>1.00</td>
<td>0.99-1.00</td>
</tr>
<tr>
<td>Parental attachment&lt;sup&gt;m&lt;/sup&gt;</td>
<td>49</td>
<td>0.99</td>
<td>0.99-1.00</td>
</tr>
<tr>
<td>School attendance</td>
<td>80</td>
<td>1.00</td>
<td>0.99-1.00</td>
</tr>
<tr>
<td>School engagement&lt;sup&gt;m&lt;/sup&gt;</td>
<td>35</td>
<td>0.99</td>
<td>0.99-1.00</td>
</tr>
</tbody>
</table>

Prevalence = Percentage of children who are exposed to the protective effect.

Moderation effect = BMI interaction with the protective factor in Model 0.

Mediation effect = Wald test for the reduction of the effect of BMI on aggression due to the inclusion of the protective factor in Model 0.

<sup>m</sup> = The protective effect for these scales occurred in the middle quartiles.

In the multivariate regression analyses (presented in Table 3), after including all risk and moderating protective factors in Model 1, the association between BMI and aggression remained significant (IRR = 1.009, 95% CI = 1.004-1.015, p = .001). The risk factor of computer use/video game play was no longer significant, suggesting that this factor did not directly predict aggression, its association explained by other factors. In Model 1, prior to the addition of interactions, parental attachment (IRR = 0.978, 95% CI = 0.964-0.992, p = .002), emotional control (IRR = 0.954, 95% CI = 0.931-0.978, p < .001), and school attendance (IRR = 0.962, 95% CI = 0.941-0.984, p = .001) were found to have protective effects, reducing the strength of the main association between BMI and aggression. Coping skills (IRR = 0.990, 95% CI = 0.974-1.006, p = .210) and school engagement (IRR = 1.077, 95% CI = 0.990-1.172, p = .085) were not shown to have protective effects in the multivariate model. In Model 2, the interactions of BMI x coping skills, BMI x parental attachment, and BMI x school engagement were included, and results demonstrated that BMI and aggression retained a significant relationship (IRR = 1.009, 95% CI = 1.004-1.015, p = .001). Whilst the main effect of coping skills did not yield a significant effect, the interaction between BMI x coping was significant (IRR = 0.995, 95% CI = 0.991-0.999, p = .016), suggesting that BMI has significantly less effect on aggression when coping skills are rated above the mid-level or
school engagement is above the lowest quartile. Parental attachment had significant main effects, but did not have significant interaction effects in the multivariate models (IRR = 0.996, 95%CI = 0.992-1.000, p = .061).

The protective effects of emotional control (IRR = 0.954, 95%CI = 0.931-0.978, p < .001), and school attendance (IRR = 0.962, 95%CI = 0.941-0.984, p = .001) were significant in Model 2, and the addition of these variables into Model 2 satisfied mediation criteria by significantly reducing the effect of BMI and aggression.
Table 3. Multivariate regression analysis predicting aggression (N = 7,288).

<table>
<thead>
<tr>
<th>Predictors</th>
<th>Model 1</th>
<th>Model 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IRR</td>
<td>95%CI</td>
</tr>
<tr>
<td><strong>BMI</strong></td>
<td>1.009</td>
<td>1.004-1.015</td>
</tr>
<tr>
<td>Age</td>
<td>0.985</td>
<td>0.975-0.996</td>
</tr>
<tr>
<td>Female</td>
<td>0.920</td>
<td>0.904-0.935</td>
</tr>
<tr>
<td>SEIFA Disadvantage Quartile</td>
<td>0.995</td>
<td>0.989-1.002</td>
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<tr>
<td><strong>Risk Factors</strong></td>
<td></td>
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<tr>
<td>Impulsivity</td>
<td>1.040</td>
<td>1.022-1.057</td>
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<tr>
<td>Alcohol use</td>
<td>1.027</td>
<td>1.018-1.037</td>
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<tr>
<td>Tobacco use</td>
<td>1.021</td>
<td>1.001-1.042</td>
</tr>
<tr>
<td>Drug use</td>
<td>1.140</td>
<td>1.065-1.220</td>
</tr>
<tr>
<td>Depressive symptoms</td>
<td>1.004</td>
<td>1.002-1.006</td>
</tr>
<tr>
<td>Junk food</td>
<td>1.017</td>
<td>1.003-1.031</td>
</tr>
<tr>
<td>Game time</td>
<td>1.009</td>
<td>0.999-1.018</td>
</tr>
<tr>
<td><strong>Protective Factors (Moderators)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coping&lt;sup&gt;m&lt;/sup&gt; X BMI</td>
<td>0.990</td>
<td>0.974-1.006</td>
</tr>
<tr>
<td>Parental Attachment&lt;sup&gt;m&lt;/sup&gt; X BMI</td>
<td>0.995</td>
<td>0.991-0.999</td>
</tr>
<tr>
<td>School Engagement&lt;sup&gt;m&lt;/sup&gt; X BMI</td>
<td>0.978</td>
<td>0.964-0.992</td>
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<tr>
<td><strong>Protective Factors (Mediators)</strong></td>
<td></td>
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<tr>
<td>Emotional control</td>
<td></td>
<td></td>
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<tr>
<td>School attendance</td>
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</tbody>
</table>

<sup>m</sup> = The protective effect for these scales occurred in the middle quartiles.
Discussion

This study presented findings from a large sample of Australian adolescents (N = 7,288) that were physically measured for height and weight and responded to valid self-report measures of aggression and risk and protective factors. Analyses enabled a unique investigation of important associations that inform the co-occurrence of adolescent health problems. As previously reported (Tso et al., 2017), a significant effect of adolescent BMI on aggression was identified, that was maintained after controlling for common risk factors. In line with hypotheses, the present study found evidence for protective effects that operated independent of risk factors as argued in the protective factor model of resilience (Garmezy et al., 1984).

The present study found a significant association between BMI and aggression in children and adolescents aged 10-14 years, consistent with previous findings (Eschenbeck et al., 2009; Griffiths, Wolke, Page, Horwood, & The ALSPAC Study Team, 2006; Janssen et al., 2004; Tso et al., 2017). In the final multivariate analysis (Model 2), a number of common risk factors maintained small, but significant effects as predictors of aggression including: impulsivity, alcohol, tobacco and other drug use, depressive symptoms and junk food consumption. The current study extended prior research by including protective factors within full multivariate models to establish their influence in modifying the effect of BMI on aggression.

In the multivariate regression analysis, the association between BMI and aggression was significantly reduced after the inclusion of protective factors, but was maintained as a significant effect. Two clear moderation relationships were identified. Relative to lower-levels, mid-levels of coping skills, and school engagement significantly reduced the association between BMI and aggression. Mid-levels of parental attachment were found to have an independent main effect on the relationship between BMI and aggression, but no
interaction effect with BMI. Emotional control and school attendance were found to fulfill mediation criteria, such that high levels of emotional control and consistent school attendance significantly reduced the strength of the relationship between BMI and aggression, but did not eradicate the significant association altogether.

**Implications for Theory**

In demonstrating that BMI maintained a significant effect on aggression, independent of risk and protective factor, the findings lend support to theories that argue that BMI makes a direct contribution to aggression. Social Dominance theories, argue that physically larger youth are tempted to use aggression as it offers them power to secure a position within their school or peer group social hierarchy (Closson, 2009; Kolbert & Crothers, 2003; Pellegrini & Long, 2002; Volk et al., 2012; Williford et al., 2011). In one sense such theories link to evolutionary theories that note aggression is used in animal populations to secure resources and survival.

In modern societies there is an important imperative to assist adolescent development to go beyond reliance on primitive aggressive responses to achieve social goals. The results also support social-ecological theories in demonstrating that there are multiple risk and protective factors across a range of adolescent social environments that directly and indirectly influence aggression, even though the relationship between BMI and aggression remained significant.

The results present one of few analyses of resiliency theories of protective factors associated with aggression in adolescents. A number of factors were found to operate as moderators or mediators of the effect of BMI on aggression. Mid-levels of coping skills were identified to have a protective moderating effect in reducing the strength of the relationship between BMI and aggression. Findings were in line with previous studies that have found a protective effect for coping skills in reducing adolescent aggression (Boggiano et al., 2015; Whitman & Gottdiener, 2015). The results of the current study extend prior research by
identifying that this protective effect is evident for around half the adolescent population with above mid-levels of coping skills. One explanation could align lower coping with the inability to identify alternatives to the primitive use of force as a maladaptive strategy to achieve desired social goals (Camodeca & Goossens, 2005; Chan & Wong, 2017; Kokkinos, Antoniadou, Dalara, Koufogazou, & Papatziki, 2013; Whitman & Gottdiener, 2015). Several studies have found that aggressive adolescents have the capacity to be psychologically well-adjusted and adept at regulating emotions and utilizing appropriate coping strategies (Berger, 2007; Juvonen, Graham, & Schuster, 2003; Volk et al., 2006; Wolke, Woods, Bloomfield, & Karstadt, 2001).

The current study also found non-linear protective effects for parent attachment. Mid-levels of parental attachment had a protective effect on the relationship between BMI and aggression, while low and high levels of parental attachment had significantly less protective effect. It is well established that low levels of parent attachment are deleterious to adolescent development (Kapoor & Tung, 2017; Keitel-Korndörfer et al., 2015). An explanation for the lack of protection for high levels of parental attachment could equate to parents that are overprotective and fail to set-limits or demand competence, failing to develop adolescents away from the use of aggression (Sharma, 2016).

The current study found that mid-levels of school engagement had a protective effect on the relationship between BMI and aggression, and that low or high levels of school engagement did not yield similar protective results. The lack of protection for adolescents that have low school engagement has been previously documented (Batanova & Loukas, 2014; Richmond et al., 2014). The lack of protective effect of highly engaged students may be associated with the use of competitive contact sports in many Australian schools. It is possible that larger BMI students that have strong links to competitive contact sports find that aspects of aggressive behavior are encouraged in their school setting (Juvonen & Ho, 2008).
Directions for Future Research

The current study confirmed a range of predictors of aggression and provided indications that the effect of BMI may be moderated and mediated by protective factors. Further research is warranted investigating this relationship in longitudinal and controlled overweight/obesity and aggression prevention trials.

Historically, much of the research in aggressive behaviors in children and adolescents has been limited to overt aggression, which includes physical behaviors intended to harm others. However, aggressive behaviors can take place in other forms, such as verbal abuse (including name-calling, teasing, and threats), or manipulative or controlling behavior (such as threatening to withdraw friendships, and rumor-spreading), both in direct face-to-face interactions and over online/internet mediums such as social media applications. Therefore, to properly address the issue of aggressive behaviors future research should investigate other forms of adolescent aggression.

The context and reasons for aggressive behavior were not explored in the current study. Future studies could examine motivations that may provide further support for Social Dominance theories of aggression in children and adolescents, and could extend existing knowledge in this area.

Whilst a number of covariates were found to have a protective effect on the relationship between BMI and aggression in children and adolescents, these factors were not sufficient to reduce the relationship between BMI and aggression to non-significance. Given that there is an abundance of literature outlining factors that are protective against aggression in children and adolescents, future studies should broaden investigations and consider additional community and societal factors that could act as risk or protective factors.

Strengths and Limitations
Strengths of the current study included: the physical measurement of height and weight; the inclusion of widely used measures of aggression and risk and protective factors; the very large national sample; and the use of multivariate modeling. An important limitation was the cross-sectional design that provides a weak basis for inferring temporal relationships and causality. As one example of the need for cautious causal interpretation, it is feasible that aggression in adolescents may precede weight gain. To better establish causation, future longitudinal and intervention studies could examine the reciprocal effects of modifying either overweight/obesity or aggression or their common determinants. The potential protective moderating and mediating effects on the association between BMI and aggression identified in the current study need to be cautiously interpreted and confirmed in future research.

A limitation of using BMI as the sole indicator of overweight/obesity is the fact that only measures of overall height and weight of the individual are taken. Factors that may affect an individual’s weight, yet are not an indicator of overweight/obesity (such as muscle mass) are not considered (Ervin et al.; Gallup et al., 2007; Hasan et al., 2016).

A second limitation of this study was the fact that the outcome variable measured high levels of physical aggression, to the extent of inflicting serious injury upon another that required medical attention, and did not accommodate outcomes that may be on a lower end of the physical aggression spectrum, such as threats to harm, or pushing/shoving. Future studies could incorporate a wider range of physically aggressive outcomes that incorporate lower levels of physically aggressive behaviours.

Conclusion

This study contributes to theories that argue that BMI is directly associated with aggression, by demonstrating this association remains significant after controlling for common risk factors and a range of protective factors. The study makes a specific contribution to research into protective factors by demonstrating moderators and mediators
for the effect of BMI on aggression. There are many adverse physical, social, and psychological effects for children and adolescents who are overweight/obese or aggressive and related financial burden placed on society. Hence, it would be pertinent for further longitudinal and intervention research to be conducted to specify the potential causal models, and to explore additional factors that may be of a protective nature against this association.
Chapter 8: General discussion and conclusions

The overall aim of this thesis was to examine the association between overweight/obesity and physical aggression in children and adolescents, and to examine risk factors that may explain the association as well as protective factors that may mitigate those risks. In order to achieve these aims, three studies were conducted: a) a meta-analysis collating available empirical research to determine if an association existed; b) a cross-sectional national study examining the association, after controlling for a number of known risk factors common to both overweight/obesity and physical aggression in children and adolescents; and c) a cross-sectional national study examining the association after including both the risk factors found to be significant from the prior study, while also modelling the effect of protective factors.

These studies demonstrated that overweight/obesity had an independent relationship with physical aggression in children and adolescents, even after controlling for a range of shared risk factors and after modelling protective factors. In what follows, the findings were discussed in terms of a number of implications, from the perspective of physical aggression intervention policies and programs.

Part One of this discussion will outline the major findings that can be drawn from the results in the aforementioned studies in the context of the existing research. Part Two will review the unique contributions the studies in this thesis have made to the existing research literature. Part Three will outline the strengths and limitations of the present studies. Finally, Part Four will discuss the implications for policy makers, educators, and health care providers.

Part 1: Major Findings

In what follows, the three major findings of this thesis are discussed: (1) The association between overweight/obesity and physical aggression in children and adolescents was not fully explained by common risk factors; (2) Overweight/obesity maintained a significant
effect on physical aggression, after also modelling protective factors; and (3) Potential mechanisms for protective effects were clarified.

**Major finding 1: The association between overweight/obesity and physical aggression in children and adolescents was not fully explained by common risk factors.** The literature review and meta-analysis (Chapter 3) found that in prior studies, overweight/obesity appeared to be a consistent risk factor for physical aggression in children and adolescents. The empirical study reported in Chapter 5, provided further support for this association. This study found that the association remained significant, even after controlling for demographic variables (such as gender, age, and SES), and common risk factors. The risk factors common to both overweight/obesity and physical aggression controlled in this study were impulsivity, alcohol/tobacco/other drug use, depressive symptoms, unhealthy food consumption, peer victimisation, television use, and computer use/video game play. This finding aligns with those of prior research outlined in Chapters 3, 4 and 5 of this thesis and confirms, beyond previous research, that the association is independent of common “shared” risk factors (Banis et al., 1988; Baum & Forehand, 1984; Datar & Sturm, 2004; Eschenbeck et al., 2009; Griffiths et al., 2006; Halfon et al., 2013; Hwang et al., 2006; Ikaheimo et al., 2007; Janssen et al., 2004; Lumeng et al., 2003; Piko et al., 2006; Raine et al., 1998; Sawyer et al., 2006; Seyedamini et al., 2012; Tremblay et al., 1998; Zeller et al., 2008).

**Major finding 2: Overweight/obesity maintained a significant effect on physical aggression, after also modelling protective factors effects.** The study of protective effects is particularly important for youth with high risk factors for aggression (Fergusson & Woodward, 2000; Samuelson et al., 2010). The multivariate analysis in the third study (Chapter 7) included common risk factors from the second study that were found to be significantly related to physical aggression, and further included protective factors that may modify the effect of overweight/obesity on physical aggression. The protective factors tested
were: emotion control (Cooley & Fite, 2016; Kelly et al., 2016), coping skills (Boggiano et al., 2015; Whitman & Gottdiener, 2015), parental attachment (Kapoor & Tung, 2017; Keitel-Korndörfer et al., 2015), positive family interactions/family connectedness (Andreas & Watson, 2009; Hooper et al., 2014), school attendance (Dalun et al., 2010; Richmond et al., 2014), and school engagement (Batanova & Loukas, 2014; Richmond et al., 2014). Results from the third study demonstrated that the association between overweight/obesity and physical aggression once again remained significant after controlling for both the common risk factors and protective factors. This analysis contributed a novel and complex multivariate model predicting adolescent aggression. The final model revealed that computer use/video game play was no longer significant as a risk factor for physical aggression after full multivariate model adjustment. This suggested that one or more of the protective factors included in the analysis mitigated this risk effect. Additionally, family connectedness was not found to demonstrate any mediation or moderation effects between overweight/obesity and aggression.

**Major finding 3: Potential mechanisms for protective effects were clarified.**

Researchers have called for protective mechanisms to be clarified (Garmezy, 1990; Luthar & Zigler, 1991; Masten et al., 2008; Rutter, 1990; Werner & Smith, 1992). The thesis contributed a novel analysis of the mechanisms of protective effects modifying the influence of overweight/obesity on adolescent aggression. Results from the third study demonstrated that coping skills and school engagement yielded significant interaction effects with overweight/obesity, parental attachment moderated the association between overweight/obesity and physical aggression, and emotion control and school attendance mediated the association between overweight/obesity and physical aggression. Relative to lower-levels, mid-levels of coping skills and school engagement significantly reduced the strength of association between BMI and aggression. Mid-levels of parental attachment were
found to have an independent main effect on the relationship between BMI and aggression, but no interaction effect with BMI. Emotional control and school attendance were found to fulfil mediation criteria, such that high levels of emotional control and consistent school attendance significantly reduced the strength of the relationship between BMI and aggression, but did not eradicate the association altogether.

**Part 2: New Contributions to the Literature**

The sections that follow summarise the novel contributions to the literature the present studies have made. These relate in the first study to a systematic review and meta-analysis (Chapter 3) quantifying the direct association between overweight/obesity and physical aggression based on data from existing empirical literature. Later papers reported in this thesis subsequently presented two empirical studies utilising a nationally representative sample of Australian children and adolescents. The second study (Chapter 5) demonstrated that the association between BMI and aggression remained significant after controlling for common risk factors and the third study (Chapter 7) that the association maintained significance in an expanded model, which also including protective factors. The results from the studies contained in this thesis provide further support for the Evolutionary and Social Dominance theories outlined in the Chapter 1.

Prior to publication of the first paper in the present thesis (Chapter 3), there had not been a systematic review or meta-analysis synthesising studies examining the direct association between overweight/obesity and physical aggression in children and adolescents. Some studies in the empirical literature examined associations between overweight/obesity and variations of physical aggression, such as generalised behavioural problems and bullying behaviour (Datar & Sturm, 2004; Griffiths et al., 2006; Janssen et al., 2004), and internalising and externalising behaviours, though very few examined the specific outcome of purely physical aggression (Eschenbeck et al., 2009; Hwang et al., 2006; Lumeng et al., 2003;
Mustillo et al., 2003; Piko et al., 2006; Pitrou et al., 2010; Sawyer et al., 2006; Seyedamini et al., 2012). There have also been inconsistencies in results, with some studies finding a significant relationship between overweight/obesity and physical aggression (Halfon et al., 2013; Raine et al., 1998; Zeller et al., 2008), while others have not (Farhat et al., 2010; Gallup & Wilson, 2009; Luukkonen et al., 2011; Pasch et al., 2008; Pitrou et al., 2010).

The first study in this thesis (Chapter 3), therefore, provided a solid foundation for further exploration by using meta-analysis to quantify the association between overweight/obesity and physical aggression in children and adolescents. To further explore the results obtained from the first study (Chapter 3), two empirical studies were conducted utilising a large-scale, nationally representative sample of Australian children and adolescents aged between 10-14 years (mean age 12 years). The sample sizes were 7,280 and 7,288 respectively for the analytic samples reported in the second (Chapter 5) and third (Chapter 7) studies.

The findings from the second study (Chapter 5) indicated that overweight/obesity maintained a significant association with physical aggression, even after controlling for demographic variables (gender, age, and SES), and for shared risk factors (impulsivity, alcohol/tobacco/other drug use, depressive symptoms, unhealthy food consumption, peer victimisation, television use, and computer use/video game play). All shared risk factors remained significantly associated with physical aggression in the adjusted model, aside from peer victimisation and television use, suggesting that the association previously found between those factors and physical aggression may be explained by the other risk factors present in the model. The results from this study extend the current research literature regarding the association between overweight/obesity and physical aggression in children and adolescents, by providing support for an independent association in an analytic model.
controlling for a variety of demographic variables and common risk factors, which were expected to explain the relationship but did not.

Further extending the research literature on predictors of childhood/adolescent aggression, a number of common risk factors were found to maintain associations with physical aggression after controlling for the effects of overweight/obesity. In particular, the results of the multivariate analysis found that impulsivity, alcohol/tobacco/other drug use, depressive symptoms, junk food/sugar consumption, and computer use/video game play maintained predictive effects on physical aggression in children and adolescents, after controlling for the effects of overweight/obesity. Whilst much of the empirical research literature suggests that an association exists between peer victimisation and physical aggression (Kochenderfer-Ladd, 2004) and television use and physical aggression (Busch et al., 2013; Kelishadi et al., 2015), the present study found that these variables (when included in the multivariate analysis with demographic variables and other covariates) were no longer significant predictors of physical aggression. This suggested that their association with aggression may be explained by other factors included in the multivariate analysis.

The findings from the present study lend additional support to the Ecological Systems Theory (EST) by demonstrating that the development of physical aggression in childhood and adolescence can be influenced by a wide range of risk factors. The risk factors examined in the analyses reported in Chapters 5 and 7, incorporated different aspects of child or adolescent ecosystems, such as those at the individual, family, and school levels.

The findings from the third study (Chapter 7) indicated that overweight/obesity maintained a significant association with physical aggression, even after controlling for demographic variables (gender, age, and SES), shared risk factors (impulsivity, alcohol/tobacco/other drug use, depressive symptoms, unhealthy food consumption, and computer use/video game play), and protective factors (coping skills, parental attachment,
school engagement, emotion control, and school attendance). Computer use/video game play was no longer a significant predictor of physical aggression in the fully adjusted multivariate model presented in Chapter 7. This suggested that the effects of computer use/video game play on physical aggression may be mitigated by other protective factors present in the model. In the full multi-variate adjusted model in Chapter 7 a number of protective mechanisms were clarified. Interaction effects between BMI and coping and BMI and school engagement suggested these variables moderated the relationship between overweight/obesity and physical aggression, as did parental attachment. Emotional control and school attendance partially mediated the association between overweight/obesity and physical aggression.

Whilst existing research suggests support for the protective nature of family connectedness against the development of physical aggression in children and adolescents (Andreas & Watson, 2009; Hooper et al., 2014), the present study did not find any moderation or mediation effects between overweight/obesity and physical aggression. This finding suggests that the protective effect of family connectedness may be explained by other protective factors that were included in the final analytic model. The results of this study extend the current research literature regarding the association between overweight/obesity and physical aggression in children and adolescents, by providing strong support that this association is maintained, despite controlling for demographic variables and a variety of common risk and protective factors. A number of the protective factors included in the analysis were found to reduce the strength of the association between overweight/obesity and physical aggression. In particular, the results of the multivariate analysis found that moderate levels of coping skills, parental attachment, and school engagement, as well as higher levels of emotional control and consistent school attendance weakened the association between overweight/obesity and physical aggression.
Extending support for Ecological, Evolutionary and Social Dominance theories. As outlined above, the results from the three studies contained in this thesis have extended the theoretical understanding of the association between overweight/obesity and physical aggression in children and adolescents. The findings provide further evidence that this association exists independently of risk factors that are common to both overweight/obesity and physical aggression. This effect was also maintained after including protective effects in multivariate regression models. The finding of a direct effect of overweight/obesity on aggression lends further empirical support for theories that outline how this may occur. In addition to the EST, Both the Evolutionary and Social Dominance theories of physical aggression were proposed as potential explanations of this association.

EST (Bronfenbrenner, 1979; Bronfenbrenner, 1994) posits that child and adolescent development is influenced by multiple developmental systems that are indicated by variables measuring individual, familial, peer, neighbourhood, school, and societal influences. As such, EST proposes that aggressive behaviour is influenced not only by factors within the immediate environment (e.g., individual and family factors), but also from more distal environments. In the present study these included the effects of school factors, which have previously been proposed to impact upon the development of child aggression (Bronfenbrenner, 1979; Bronfenbrenner, 1994). The third study in this thesis (Chapter 7) included not only the common risk factors found to be significant in the second study, but also protective factors (such as coping skills, parental attachment, school engagement, emotional control, and school attendance). This study contributed novel insights into how protective factors contributed to modifying the effect of BMI on physical aggression. The results provided further support for the basic premise of EST; that is, that a variety of factors proximal and distal to a child/adolescent can moderate and mediate the effects of obesity/overweight in the development of aggressive behaviour.
Despite the contributions made by common risk and protective factors to the strength of the association, the relationship between overweight/obesity and physical aggression remained significant in the multi-variate adjusted models (Chapters 5 and 7). These results lend support for Evolutionary and Social Dominance theories.

Evolutionary theory posits that physical aggression in children and adolescents functions as a means of obtaining easier access to resources such as nutrition, mates, and defence against predators (Kolbert & Crothers, 2003). Aggression may also be motivated to acquire social advantages within a hierarchy (involving the development of a reputation within a social group of strength and dominance, which in turn leads to material resources which may increase attractiveness to the opposite gender for reproductive purposes) (Archer & Benson, 2008). The application of Social Dominance theory, while similar to Evolutionary theory, is extended to apply to more modern contexts, where social dominance may refer to competition for toys in childhood (Smith & Connolly, 2010), and for gaining favour from peers and potential sexual partners in adolescence (Pellegrini & Bartini, 2001; Pellegrini & Long, 2002).

In the full multivariate analysis (Chapter 7), protective factors were found to significantly reduce the strength of the association between overweight/obese and physical aggression. The findings revealed that protective factors such as mid-levels of coping skills, parental attachment, and school engagement and the mediating effects of emotional control and school attendance reduced the association between overweight/obesity and physical aggression. These findings suggest that the tendency for physical size to lead to aggression can be partially reduced by encouraging higher human development through building positive and supportive home and school environments, and by encouraging higher order internal regulation (such as the building of coping skills to be utilised during times of stress). It may be that building and fostering these social relationships and skills can assist to partly mitigate
overweight/obese youth engaging in physically aggressive behaviour. The results of the studies contained in the current thesis have many implications for extending the research on Evolutionary and Social Dominance theories of physical aggression, and can assist in informing policy makers, health care professionals, and those in the education sector with methods of early intervention to reduce the development of physical aggression in children or adolescents who are overweight/obese.

**Part 3: Strengths and Limitations of the Thesis Studies**

To the author’s knowledge, this is the first study in the empirical literature examining the association between overweight/obesity and physical aggression in children and adolescents within a large, nationally representative sample, and with the inclusion of shared risk factors and protective factors. As such, the studies contained in this thesis make significant novel contributions to the current research literature around overweight/obesity and physical aggression in children and adolescents.

The studies presented in this thesis have many methodologically sound design features including a strong nationally representative cross-sectional data set with high recruitment across demographic groups representing the socioeconomic variation of Australian children (Williams et al., 2015). In overview, the designs across the three studies held the advantage of offering two perspectives based on: a meta-analysis of empirical studies from international samples; and an Australian study of children and adolescents customised to physically measure weight and height and to obtain reliable self-reports of physical aggression. The combination of these different methods provided a comprehensive basis for examining the association between overweight/obesity and physical aggression in children and adolescents.

A number of limitations are important to note. Firstly, although the results of the three studies contained within this thesis provide compelling support for a consistent association between overweight/obesity and physical aggression in children and adolescents, the cross-
sectional nature of the empirical data, limits the potential to infer causality. For example, neither the studies included in the first meta-analysis study (Chapter 3) nor the data set utilised in the two empirical analyses (Chapters 5 and 7) utilised an intervention design to examine whether a reduction in overweight/obesity ultimately leads to a reduction in physical aggression. To better establish causation, future research could utilise a longitudinal and intervention design to investigate any reciprocal effects by using interventions to modify either overweight/obesity (Amini et al., 2016; Maatoug et al., 2017; Mohammadi et al., 2017; Nigg et al., 2016; Ranucci et al., 2017), physical aggression (Kärnä et al., 2011; Midgett & Doumas, 2016; Palladino, Palladino, Nocentini, & Menesini, 2016), or their common determinants such as: impulsivity (DuPaul, Eckert, & Vilardo, 2012; Hoza et al., 2015; Smith et al., 2013), depressive symptoms (Gillham et al., 2012; Gillham et al., 2006; Kiluk, Weden, & Culotta, 2009; McDowell, MacDonncha, & Herring, 2017; McMahon et al., 2017), alcohol/tobacco/other drug use (Allen et al., 2016; Butzer, LoRusso, Khalsa, & Shin, 2017; Conrod, O’Leary-Barrett, Newton, & et al., 2013; Hodder et al., 2017; MacArthur, Harrison, Caldwell, Hickman, & Campbell, 2016; O’Leary-Barrett, Mackie, Castellanos-Ryan, Al-Khudhairy, & Conrod, 2010), and junk food/sugar consumption (Bjelland et al., 2015; Skouteris, Hill, McCabe, Swinburn, & Busija, 2016; Van Cauwenberghe et al., 2010; Van Lippevelde et al., 2012)). This would also disentangle the issue of causality, as well as establish whether there may be a bi-directional relationship between overweight/obesity and physical aggression.

Secondly, the general and widely-used measure of overweight/obesity in the developmental literature is BMI (Aeberli et al., 2013; Mercado-Crespo & Mbah, 2013). A limitation of using BMI as the sole indicator of overweight/obesity, however, is the fact that only measures of overall height and weight of the individual are taken. Factors that may affect an individual’s weight and aggression, such as muscle mass are not considered. Indeed,
some studies have demonstrated that BMI may be positively correlated with increased muscle strength (and therefore, mass) (Ervin et al., 2014; Gallup et al., 2007; Hasan et al., 2016). Muscle strength is also associated with aggression (Gallup et al., 2007). As such, measures of waist circumference (Aeberli et al., 2013; Daniels, 2009; Freedman & Sherry, 2009) and skinfold thickness tests (Freedman & Sherry, 2009) conducted in addition to a calculation of BMI would increase the sensitivity and accuracy of measurements of overweight/obesity in future research into the effects on aggression.

Thirdly, the age of the data set (which was collected in 2006) is a potential limitation of the two empirical studies contained in this thesis; however, it is unlikely that this factor had a significant impact on the results. The literature review presented in Chapter 1 together with the studies included in the meta-analysis presented in Chapter 3 (which spanned from 1984 to 2013) suggest that the associations between overweight/obesity and physical aggression have remained robust across studies over the last three decades.

Fourthly, as the data set utilised in the second (Chapter 5) and third (Chapter 7) studies was obtained through self-report means, a limitation of this thesis is the possibility of shared method variance. The inclusion of the use of a fictitious drug attempted to counteract effects of any of the participants responding falsely to the use of illicit drugs; however, this measure was not able to be implemented for a number of other variables that were measured and under investigation. Future research could consider including reports from peers, teachers, and parents in order to minimise shared variance effects as a result of solely relying on self-report data.

Finally, as mentioned in the Limitations sections of Study 2 (Chapter 5) and Study 3 (Chapter 7), the outcome variable measured was that of extreme physical aggression, and did not account for lower levels of physical aggression which may not have been serious enough to warrant medical attention, such as pushing/shoving and threats to harm. Future studies
could also explore other forms of aggression such as verbal, relational, and cyber aggression. Additionally, motivations behind engaging in physical aggression were not measured, and it is possible that differentiating between proactive and reactive physical aggression (where physical aggression is used as a response rather than as an initiated behaviour) may have provided further insight into a relationship between peer victimisation and physical aggression.

**Part 4: Implications**

The present thesis provides an important advance to efforts to understand the potential consequences of overweight/obesity for child and adolescent development. The meta-analysis provided the first quantitative summary of prior research that has been conducted specifically focussing on the association between overweight/obesity and physical aggression in children and adolescents. Although overweight/obesity prevention initiatives are not a novel idea, much emphasis of the research and interventions in this area have been aimed at improving physical health. There has been less research investigating the potential mental health or behavioural benefits. Aside from the serious physical health implications of overweight/obesity (such as sleep apnoea, orthopaedic and gastrointestinal problems (National Health and Medical Research Council, 2013), and development of cardiovascular disease, diabetes, musculoskeletal disorders, and some cancers in adulthood (World Health Organization, 2014)), there are many psychosocial effects. These include issues such as being subject to victimisation by peers, which may then lead to poor peer and school experiences, resulting in negative developmental effects (National Medical Health and Research Council, 2013; Griffiths et al., 2006; Hayden-Wade et al., 2005; Sawyer et al., 2006). In addition to these effects, the results of the three studies contained in this thesis suggest that engaging in physically aggressive behaviour is another potential effect of being overweight/obese in childhood or adolescence.
From a prevention perspective, the current findings suggest that some interventions to reduce child and adolescent body weight or obesity may reduce risk factors that lead to physical aggression including: BMI, junk food/sugar consumption and sedentary behaviours that associate with video game use, impulsivity and depression. Several empirical studies utilising a school-based approach incorporating nutrition education, physical activity, and change in the items sold in school canteens, have demonstrated some effectiveness in reducing student body fat, BMI and obesity (Amini et al., 2016; Maatoug et al., 2017; Mohammadi et al., 2017; Waters et al., 2011). Interventions utilising family-based approaches have also been identified to reduce overweight/obesity by incorporating nutrition education, physical exercise, and psychological counselling sessions with the child’s family members (Ranucci et al., 2017). Interventions that incorporate a combination of both family and school approaches have also been shown to be effective (Amini et al., 2016; Nigg et al., 2016). These findings suggest that the implementation of interventions targeted at reducing youth overweight/obesity may also have benefits in reducing physically aggressive behaviour.

There is evidence in the research literature outlining the effectiveness of school-based programs that target bullying (which includes acts of physical aggression against peers) (Farrington & Ttofi, 2009; Ttofi & Farrington, 2011). These involve various components of interventions targeted at different levels of influence such as individual students, parents, teachers, and whole schools (Menesini & Salmivalli, 2017). Based on the results of the three studies presented in this thesis, youth physical aggression interventions can be targeted at the different levels of EST influence. A number of risk factors were identified to maintain direct effects on aggression in the fully adjusted multivariate model. More specifically, the third study found that impulsivity, alcohol/tobacco/other drug use, depressive symptoms, and junk food/sugar consumption maintained direct effects on aggression. These findings suggest that
prevention and early intervention efforts targeting these risk factors in children and adolescents may be effective in mitigating the risk for developing physically aggressive behaviours.

A number of studies have documented success in reducing symptoms of impulsivity in children and adolescents through increased physical activity programs implemented within schools (Hoza et al., 2015; Smith et al., 2013). Physical activity has been shown to be associated with neurocognitive function, and linked to the preservation and enhancement of cognitive function, particularly of executive control processes (Hall, Smith, & Keele, 2001; Kramer, Colcombe, McAuley, Scalf, & Erickson, 2005). This is relevant to the current research, given that childhood/adolescent impulsivity is related to executive control deficits (Smith et al., 2013). Additionally, other school-based interventions, such as cognitive-behavioural intervention strategies (focussing on the development of self-control skills and reflective problem-solving strategies) have been found to significantly assist with behaviour regulation, particularly if implemented in conjunction with physical activity programs (DuPaul et al., 2012).

Increased physical activity has also been implicated in the effectiveness of reducing symptoms of depression in children and adolescents (Kiluk et al., 2009; McDowell et al., 2017; McMahon et al., 2017), with a number of explanations offered for this link. Regular engagement in a challenging activity may lead to an increase in an individual’s confidence and subsequently to a decrease in depressive symptoms (Paluska & Schwenk, 2000). The social relationships developed from regular participation in physical activity may also improve mental health (Monshouwer, ten Have, van Poppel, Kemper, & Vollebergh, 2013). In addition to physical activity, school-based cognitive-behavioural programs (designed to teach cognitive and problem-solving skills to children and adolescents) have evidence for reducing depressive symptoms in children and adolescents (Gillham et al., 2006). Programs
that integrate school-based social relationship/emotional health education and parent/caregiver parenting education (Gillham et al., 2012) have also been found to be effective in reducing depressive symptoms in children and adolescents.

There is also empirical evidence supporting the use of both school-based (enforced by teaching staff), peer, and parenting interventions for reducing tobacco, alcohol, and other drug use. Low-intensity group parenting interventions implemented through in-person sessions with parents and youth together have been found to be effective at reducing or preventing adolescent substance use, and the effects may persist for a number of years post-intervention (Allen et al., 2016). School-based interventions appear to be the most common within the research literature, and include interventions to build resilience (Hodder et al., 2017; Toumbourou, Gregg, Shortt, Hutchinson, & Slaviero, 2013) and teacher-delivered personality-targeted interventions. The latter interventions are aimed at children and adolescents with elevated levels of personality risk factors for substance use, such as sensation-seeking, impulsivity, anxiety sensitivity, and hopelessness (Conrod et al., 2013; O'Leary-Barrett et al., 2010). Other interventions including yoga classes (Butzer et al., 2017), and peer-led interventions (MacArthur et al., 2016) have also demonstrated effectiveness in reducing or preventing youth substance-use.

Interventions relating to junk food/sugar consumption appear to have resulted in the highest level of success when a combination of school and home interventions are applied. Schools provide many opportunities to promote healthy eating habits through school food services and health education classes (Van Cauwenberghe et al., 2010). Home-based interventions that include parental involvement (such as increasing the availability of and accessibility to healthy food products as well as providing modelling opportunities) have also been shown to increase healthier food consumption and to decrease unhealthy snacking behaviour (Bjelland et al., 2015; Skouteris et al., 2016; Van Lippevelde et al., 2012).
Results from the current thesis provide further support for the notion that childhood aggression can be tackled from many levels of a child/adolescent’s ecosystem. Prior studies confirm, that the incorporation of school, family and peer interventions demonstrate some effectiveness in reducing risk factors for physical aggression.

Some individual-level interventions have also found support in assisting with reductions in physically aggressive behaviours. In some cases these interventions appear to reduce risk factors identified in the current thesis. For example, there is some evidence that utilising a problem-solving or skills-training based framework to teach those who are physically aggressive to use alternative, pro-social means of attaining their desired goals, can be effective in reducing aggressive behaviour (Volk et al., 2012). In one study, the goal of achieving social dominance and popularity within one’s peer group was achieved by defending victims from bullies, or by excelling in physical fitness and sporting activities (Volk et al., 2012). What is paramount to the success of this approach is an understanding of the goals of the perpetrator of physical aggression, and the demonstration of problem-solving, alternative pro-social strategies as an alternative means to achieve those goals (Volk et al., 2012).

Another perspective that is a proximal system to the individual is that of the peer group. This is an area relatively new to the research literature and was not included in the final multivariate models. A study conducted by Salmivalli (1999) yielded findings that suggested that bullying may be a group phenomenon that is, in fact, largely enabled and sustained by peers within the school environment. Peers were found to adopt different participant roles in bullying, such as bystanders, reinforcers, instigators (of the bullying), and defenders (of the victim), and that peer actions can be powerful moderators of bullying in school (Salmivalli, 1999). In particular, individuals who witness acts of aggression against peers but do not intervene (bystanders) have been targeted in recent research as a means of bullying
prevention through enhancement of awareness, empathy, and self-efficacy to support victimised peers (Kärnä et al., 2011).

There is some evidence to suggest that youth with high risk factors for aggression, such as BMI, may be assisted through bystander interventions. Several studies have found that youth who have been given bystander interventions increase their confidence levels that they would act in defence of a peer being bullied (Midgett & Doumas, 2016; Nickerson, Aloe, Livingston, & Feeley, 2014). Bystander interventions appear to operate by decreasing anxiety and negative perceptions of peers (Williford et al., 2011), by increasing empathy, and by strengthening a commitment to intervene, on behalf of victims. Kärnä et al. (2011) conducted a study into the effectiveness of the KiVa Anti-bullying Program, which emphasised enhancing the empathy, self-efficacy, and anti-bullying attitudes of bystanders, who are neither bullies nor victims. They found in their sample of 8,237 children (aged 10-12 years) that this intervention had significant beneficial effects on self- and peer-reported victimisation, as well as self-reported bullying (Kärnä et al., 2011). Similarly, Palladino et al. (2016) conducted a study into a school-based intervention that utilised a peer-led approach to prevent and combat both traditional and cyber-bullying, where peer educators assumed a role of responsibility both in their classroom and online after undergoing specific training. The intervention implemented in this study significantly predicted change over time in victimisation, bullying, cyber-victimisation, and cyber-bullying (Palladino et al., 2016).

The implications of the above studies suggest that peers should be targeted in bullying prevention efforts. As relevant to the current thesis, these findings raise the prospect that higher BMI youth may be encouraged to take action against bullying both informally in their daily interactions with others and even formally as peer counsellors for both perpetrators and victims (Salmivalli, 1999).
The findings from the third study (Chapter 7) of this thesis indicated that school engagement and school attendance offer some protective effects against physically aggressive behaviours. This provides further support for the existing literature demonstrating a protective effect for school engagement (Batanova & Loukas, 2014; Crosnoe et al., 2002) and school attendance (Dalun et al., 2010; Wang et al., 2005) in reducing physically aggressive behaviour. The implications of these findings suggest that the perpetration of physical aggression by young people can also be addressed from a broader whole-school perspective by implementing interventions involving both teachers and peers in order to increase school attendance and school engagement. A number of recent studies in the empirical research literature have found consistent links between peer group acceptance at school and both school attendance (Rambaran et al., 2017) and school engagement (De Laet et al., 2015; Engels et al., 2017; Raufelder, Sahabandu, Martínez, & Escobar, 2015). Similarly, associations have also been found between positive relationships with teachers (in the form of motivational support) and increased school attendance and engagement (Bakadorova & Raufelder, 2017; De Laet et al., 2015; Raufelder et al., 2015). In light of this research, aggression prevention interventions should be introduced within the school environment to promote both positive and supportive teacher-student relationships and acceptance among students within their peer groups and within the classroom environment. Studies have also found that students with a positive perception of the school environment, are less likely to engage in externalising or aggressive behaviours (Christine et al., 2008; Espelage, Bosworth, & Simon, 2000; Goldweber, Waasdorp, & Bradshaw, 2013).

Other aspects that promote a stronger pro-social school environment involve increased supervision by adults of the school grounds. Research has also suggested that in addition to implementing anti-bullying programs for students, playground supervision was one of the elements that were more strongly related to program effectiveness. These findings address the
fact that victimisation tends to take place on school grounds during unsupervised periods (such as recess and lunchtime) (Ttofi & Farrington, 2011). Hence, improving the school playground environment through the reorganisation and identification of ‘hot spots’ that perpetrators and victims of bullying frequent, may be an additional component of an overall model aimed at reducing physical aggression (Ttofi & Farrington, 2011).

In overview, the above discussion reveals that many of the risk factors maintained in the multivariate model predicting aggression (Chapter 7) have been shown to be amenable to intervention. These findings are promising in supporting the potential for future interventions to be designed and evaluated based on the integration of both obesity and physical aggression prevention targets.
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