Early childhood physical activity, sedentary behaviors and psychosocial well-being: a systematic review

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Abstract

Objectives: Little is known about how health behaviors such as physical activity (PA) and sedentary behaviors (SB) may be associated with psychosocial wellbeing during the crucial early childhood period. The aim of this study was to undertake a systematic review of associations between PA, SB and psychosocial wellbeing during early childhood.

Methods: In February 2013, MEDLINE, PsycINFO, SPORTDiscus and Embase electronic databases were searched. Inclusion criteria were: 1. Peer-reviewed publication since 1980 in English; 2. Children aged birth-5y; 3. PA or SB measured during early childhood; 4. An indicator of child psychosocial wellbeing; awnd 5. Association between PA/SB and psychosocial wellbeing reported. Studies could be observational or interventions. Data were extracted by one author and entered into a standardized form in February and March 2013.

Results: 19 studies were identified: four examined PA, 13 examined SB and two examined PA and SB. No interventions met the inclusion criteria; all included studies were observational. In total, 21 indicators of psychosocial well-being were examined, 13 only once with the remaining eight reported in more than one study. Some dose-response evidence was identified suggesting that PA is positively, and SB inversely, associated with psychosocial well-being.

Conclusions: Too few studies exist to draw conclusions regarding associations. Future high-quality cohort and intervention studies are warranted particularly investigating dose-response associations.

Keywords: Early childhood; physical activity; electronic screen use; psychosocial well-being; systematic review.

Introduction

Early childhood (i.e., birth through five years) is a crucial developmental period, during which foundations for health behaviors, such as physical activity (PA) and sedentary behaviors (SB) including television viewing, are formed (Birch and Fisher, 1998). Participation in PA and SB during early childhood is associated with biomedical health outcomes such as weight, bone health and CVD risk factors (Leblanc et al., 2012; Timmons et al., 2012), cognitive development, mental function, academic achievement (Singh et al., 2012; Tomporowski et al., 2008; Tomporowski et al., 2011) and psychosocial well-being (Lotan et al., 2005; Lubans et al., 2012) in young and older children and adolescents such that higher PA and lower SB support healthier outcomes.

Several countries now have PA and SB recommendations for early childhood. For instance, Canadian, Australian, and UK guidelines recommend children younger than school age capable of walking should accumulate three hours of PA each day, while USA guidelines suggest two hours (Department of Health and Aging (DoHA), 2010; Department of Health Physical Activity Health Improvement and Protection, 2011; Tremblay et al., 2012a). With respect to SB, children younger than 2 years are recommended to participate in no screen time (Canada/Australia/USA), while recommendations for children older than 2 who have not yet started school vary between less than one hour (Canada/Australia) (Department of Health and Aging (DoHA), 2010; Tremblay et al., 2012b) and less than two hours (USA) (American Academy of Pediatrics, 2011; American Academy of Pediatrics Committee on Public Education, 2001) per day. However, there is a lack of dose-response evidence available in the extant literature (Leblanc et al., 2012; Timmons et al., 2012).

Participation in recommended levels of PA and SB may also support psychosocial well-being in young children (Leblanc et al., 2012; Timmons et al., 2012). PA is bodily movement produced from the contraction of skeletal muscles which results in energy expenditure raised above the resting level (Caspersen et al., 1985). SB is any behavior performed in a sitting or lying position with energy expenditure ≤1.5 times resting levels (Sedentary Behaviour Research Network, 2012). Subjective well-being, primarily used in the psychological literature, includes the presence of positive and the absence of negative affect (Diener, 1984). However, well-being is a multifaceted construct in the broader health literature, yet lacks a clear definition or agreement upon its constructs or interpretation (de Chavez et al., 2005; Guerin, 2012). It has been used to capture constructs such as positive and negative affect,

satisfaction with life, subjective well-being, and psychological well-being, as well as being used interchangeably with the terms quality of life and vitality (Guerin, 2012). For the purposes of this review, psychosocial well-being is considered to be the presence of higher levels of positive, and lower levels of adverse, psychological and social attributes and behaviors (e.g. social skills, physical aggression and attention problems; see psychosocial well-being search string in Table 1 for a complete list of terms used). The purpose of this definition is to assess a continuum of psychosocial well-being experienced by young children rather than identify clinical symptoms. More positive psychosocial well-being indicators in early childhood have been shown to be inversely associated with later depression, hostile behavior and aggressive interpersonal behavior (Jones et al., 2011; Meagher et al., 2009; Toumbourou et al., 2011), and may also support children's positive behavioral, social and academic outcomes during later childhood (McCabe and Altamura, 2011; Sanson et al., 2009). Therefore, supporting the development of healthy psychosocial well-being during early childhood is important for children's later development and mental health.

INSERT TABLE 1 ABOUT HERE

Previous reviews focusing on associations of PA and SB with aspects of psychosocial well-being have been reported for older children and adolescents (Costigan et al., 2013; Ekeland et al., 2004; Gapin et al., 2011) and adults (McAuley and Rudolph, 1995; Teychenne et al., 2008, 2010); however, none have been undertaken in the early childhood period. Associations of early childhood PA and SB with a broad range of health and developmental outcomes, including some indicators of psychosocial well-being, have previously been reviewed (Leblanc et al., 2012; Timmons et al., 2012). Those reviews reported a positive association between increased PA (Timmons et al., 2012), and an inverse association between increased TV viewing, and indicators of psychosocial health (Leblanc et al., 2012). However, the criteria for those reviews excluded cross-sectional investigations, which provide important epidemiological information particularly in an emerging field such as this. Additionally, those reviews included a very narrow range of psychosocial well-being terms. Specifically, the PA review (Timmons et al., 2012) included only six terms plus temperament, and the SB review (Leblanc et al., 2012) included only five terms plus personality, both of which are considered a trait rather than an indicator of psychosocial well-being. Therefore, those reviews potentially missed important outcomes (a total of 20 included in this review) as indicators of psychosocial wellbeing and subsequently included only a

small number of studies (three PA (Timmons et al., 2012) and six SB (Leblanc et al., 2012)) from the wider body of literature in this field. By adopting a more inclusive definition of psychosocial well-being and a broader range of study designs, as this review does, a more comprehensive and thorough investigation of associations of PA and SB from a young age on this health outcome is possible. Additionally, those reviews incorporated various other health outcomes, such as obesity and bone health, limiting their ability to investigate psychosocial well-being outcomes in depth. Due to such limitations, those two reviews do not provide a comprehensive overview of the extant literature for studies focusing on PA, SB and psychosocial well-being. The purpose of this paper is to review both observational and intervention literature investigating potential associations between both PA and SB and children's psychosocial well-being during the early childhood period.

Methods

Search strategy & information sources

In February 2013 a systematic search for original research articles was conducted using MEDLINE, PsycINFO, SPORTDiscus and Embase electronic databases. Four separate search strings relating to 1. physical activity, 2. sedentary behaviors, 3. early childhood and 4. psychosocial well-being were utilized. Table 1 provides the full search strategy for PsycINFO which was modified where necessary for the remaining databases. Reference lists of relevant studies and reviews were further examined, as were links to related articles within databases. Studies from the authors' own collections were searched. The PRISMA Guidelines and recommendations for reporting of systematic reviews were followed (Moher et al., 2009). The search strategy was created and run by TH with the help of a library and information services expert. References were imported directly into Endnote X6 (Thompson Reuters, California, USA). Duplicate articles were removed using Endnote; any remaining duplicates were manually removed.

The review process included four steps: 1. The title of each article was examined by one author (TH) to identify those eligible for inclusion. 2. To assess the reliability of this author accurately identifying all titles which may be eligible for further review, the titles of a random selection of 10% of the total number of titles was subsequently examined by another author (MT) and no additional articles were identified for inclusion. 3. The abstracts of identified articles were examined and a full-text copy of each article which met these initial

screening criteria was obtained and assessed. Titles and abstracts were examined for relevance to the topic according to the search terms. 4. Full-text articles were examined by TH and KD. Discrepancies were resolved with discussion and consensus. Where consensus was unable to be reached (on three occasions), a third reviewer (MT) examined the article and the majority opinion was taken.

Inclusion/exclusion criteria

Both observational (cross-sectional, cohort) and intervention (randomized controlled trials [RCT's] and non-randomized trials) studies were included. Inclusion criteria were:

1. Published in a peer-reviewed English language journal since 1980 (virtually no research was undertaken in this population for PA or SB prior to that time);

2. Mean age of the children was younger than six years and they were categorized as prior to elementary/primary school entry or, if age was not specified, they were categorized as being prior to elementary/primary school commencement to align with international PA and SB guidelines which cover children from birth through 5 years. This criteria needed to apply to at least the baseline age of children in intervention or cohort studies;

3. The study included a measure of PA (e.g., accelerometer) and/or SB (e.g., TV) during the early childhood period (as defined in #2 above). Studies including only parent reports of fidgeting or other active temperament characteristics as a PA/SB indicator were excluded as they do not meet the operational definition of PA outlined above and used in this paper. Public health guidelines recommend supporting PA and limiting children's SB, particularly electronic media use. To the best of the authors' knowledge, there are no recommendations to limit reading or other SBs acknowledged to have educational or other benefits. Therefore, the criteria included only those behaviors which align with recommendations providing information important to existing public policy;

4. The study included a measure of child psychosocial well-being (e.g., social skills, physical aggression or attention problems); and

5. The study included a measure of association between either PA or SB as an independent variable with one or more indicators of psychosocial well-being as the dependent variable.

Papers in press could be included; however, abstracts, case studies and theses (where peer review status is not always established) were not eligible. Studies investigating special population groups (such as children with diagnosed conditions, e.g., Autism Spectrum Disorder) were also excluded as such underlying conditions may impact on children's psychosocial well-being and/or PA or SB making it difficult to determine the effects of PA or SB on well-being for the general population. Special populations would need to be reviewed as a separate group(s) which is outside the scope of the current review

Data extraction

All data extraction and assessment took place in February and March 2013. Methodological variables, including study design, sample characteristics and findings, were extracted by one reviewer (KD) and entered into a standardized form. Clarification was sought from another author (TH) where necessary. Results were examined in terms of the statistical association ($p<0.05$) between PA and SB with psychosocial well-being. Full details of methodological variables extracted from studies and details of the included studies themselves are presented in Tables 2 (PA) and 3 (SB).

INSERT TABLES 2 & 3 ABOUT HERE

Methodological quality and risk of bias assessment

A published six-component rating scale (National Collaborating Centre for Methods and Tools, 2008 (Updated 13 April, 2010)) was modified and used to assess study quality and determine risk of bias. That tool assesses six methodological components of research studies: selection bias (e.g., representativeness), study design (e.g., RCT), confounders (e.g., controlling for confounders such as education), blinding (e.g., outcome assessor aware of group allocation), data collection methods (valid, reliable), and withdrawals and dropouts (e.g., were they reported). For those observational studies which were assessed, the tool was modified such that those studies were not scored on the blinding component or other intervention-specific criteria within any of the components. Each of the five (for observation studies) or six (for intervention studies) components was given an overall quality score of

weak, moderate or strong, in accordance with instructions accompanying the tool. If a component was not described it was given a weak rating. Once each component was rated, an overall rating of weak (if two or more of the components were scored weak), moderate (if fewer than three [observation studies] or four [intervention studies] components were scored strong with no more than one weak score), or strong (if three [observation studies] or four [intervention studies] or more components were scored strong) was given to each study. Studies of weak methodological quality were determined to have high risk of bias, and those with strong methodological quality to have low risk of bias. TH and MT both independently scored each of the studies against the quality criteria and any discrepancies in ratings were discussed until consensus was reached. Inter-rater reliability was determined by calculating Cohen's Kappa coefficient. Independent *t*-tests were used to assess differences in the number of significant findings between weak and moderate quality studies (no studies were identified which rated a strong methodological quality).

Results

In total, 16,484 citations (SPORTDiscus: 133; Medline: 4036; Embase: 9281; PsycINFO: 2440) were initially identified from the database searches and a further 466 from the authors' personal collections, totaling 16,950 titles (Figure 1). Subsequently, 2,256 duplicates and 2,674 studies investigating special population groups such as those with Autism Spectrum Disorder, Prader-Willi Syndrome or Down Syndrome, were removed, leaving 12,020 titles for review. Subsequently, 821 studies were identified as potentially meeting the inclusion criteria. Abstracts of those papers were examined and 107 were found to be potentially eligible for inclusion and the full papers were obtained. Finally, 19 met the inclusion criteria and were included in this review.

INSERT FIGURE 1 ABOUT HERE

One of the included studies was published in 1994 (Fagot and O'Brien, 1994) and more than half (n=10) were published since 2009. Nine studies were cross-sectional (Conners-Burrow et al., 2011; Ebenegger et al., 2012; Griffiths et al., 2010; Krejci et al., 2011; Lindsey and Colwell, 2003; Manganello and Taylor, 2009; Miller et al., 2007; Yu et al., 2010, 2012) and 10 were cohort studies (Cheng et al., 2010; Christakis et al., 2004; Fagot and O'Brien, 1994; Foster and Watkins, 2010; Martin et al., 2012; Mistry et al., 2007; Pagani et al., 2010; Stevens and Mulsow, 2006; Tomopoulos et al., 2007; Zimmerman et al., 2005). No

intervention studies were identified that met the inclusion criteria. The majority (n=12) of studies were conducted in the United States (Christakis et al., 2004; Conners-Burrow et al., 2011; Fagot and O'Brien, 1994; Foster and Watkins, 2010; Lindsey and Colwell, 2003; Manganello and Taylor, 2009; Martin et al., 2012; Miller et al., 2007; Mistry et al., 2007; Stevens and Mulsow, 2006; Tomopoulos et al., 2007; Zimmerman et al., 2005), two in Australia (Yu et al., 2010, 2012), and one each in Canada (Pagani et al., 2010), the United Kingdom (Griffiths et al., 2010), Switzerland (Ebenegger et al., 2012) and Japan (Cheng et al., 2010). One study compared data from Japan and the Czech Republic (Krejci et al., 2011).

The ages of children included in the cross-sectional studies ranged from 36 months to 5.2 years. Cohort baseline ages ranged from 4 months to 4 years and follow-up periods were two months to seven years. More than half the studies (n=11) utilized samples of greater than 1000 children.

Summaries of each of the included studies are presented in Tables 2 (PA) and 3 (SB). Of the included studies, four examined PA, 13 examined SB, and two examined both PA and SB. PA measures included direct observation (Fagot and O'Brien, 1994; Lindsey and Colwell, 2003), parental survey (Griffiths et al., 2010), parental time use diary (Yu et al., 2010, 2012) and accelerometry (Ebenegger et al., 2012). The majority of studies measured SB by parental survey (12 studies (Cheng et al., 2010; Christakis et al., 2004; Conners-Burrow et al., 2011; Foster and Watkins, 2010; Griffiths et al., 2010; Krejci et al., 2011; Manganello and Taylor, 2009; Martin et al., 2012; Mistry et al., 2007; Pagani et al., 2010; Stevens and Mulsow, 2006; Zimmerman et al., 2005)), with the remaining studies using parental 24-hour recall interview (Tomopoulos et al., 2007), parental semi-structured interview (Miller et al., 2007) and accelerometry (Ebenegger et al., 2012).

More than one study investigated each of the following indicators of psychosocial well-being: aggression (Manganello and Taylor, 2009; Martin et al., 2012; Pagani et al., 2010; Tomopoulos et al., 2007), attention problems (Christakis et al., 2004; Foster and Watkins, 2010; Martin et al., 2012), conduct problems (Griffiths et al., 2010; Yu et al., 2010, 2012) hyperactivity/ inattention (Ebenegger et al., 2012; Griffiths et al., 2010; Tomopoulos et al., 2007), problem behavior (Conners-Burrow et al., 2011; Fagot and O'Brien, 1994), ADHD (Miller et al., 2007; Stevens and Mulsow, 2006), emotional symptoms (Griffiths et al., 2010; Pagani et al., 2010), and social skills (Conners-Burrow et al., 2011; Mistry et al., 2007). Eight studies (Conners-Burrow et al., 2011; Fagot and O'Brien, 1994; Griffiths et al., 2010; Lindsey

and Colwell, 2003; Martin et al., 2012; Mistry et al., 2007; Pagani et al., 2010; Tomopoulos et al., 2007) included more than one measure of psychosocial well-being. More than half the studies (n=13) utilized only parent report of those measures of psychosocial well-being (Cheng et al., 2010; Christakis et al., 2004; Ebenegger et al., 2012; Fagot and O'Brien, 1994; Foster and Watkins, 2010; Griffiths et al., 2010; Krejci et al., 2011; Manganello and Taylor, 2009; Mistry et al., 2007; Tomopoulos et al., 2007; Yu et al., 2010, 2012; Zimmerman et al., 2005). Three studies utilized only teacher report (Conners-Burrow et al., 2011; Pagani et al., 2010; Stevens and Mulsow, 2006) and one each used both parent and child reports (Martin et al., 2012), parent and teacher reports (Miller et al., 2007), and parent, child and teacher reports (Lindsey and Colwell, 2003) of child psychosocial well-being.

Methodological quality and risk of bias

Methodological quality/risk of bias scores are provided in Tables 2 and 3. Initial agreement between reviewers was 74.01% (κ=0.66) on the 304 items scored. No studies received a strong overall methodological rating. Seven studies (one cross-sectional, six cohort) received a moderate overall methodological rating and 12 (six cross-sectional, six cohort) received a weak methodological/high risk of bias rating. With regard to selection bias, just over half the studies (two cross-sectional, nine cohort) included a representative sample (Christakis et al., 2004; Foster and Watkins, 2010; Griffiths et al., 2010; Manganello and Taylor, 2009; Martin et al., 2012; Mistry et al., 2007; Pagani et al., 2010; Stevens and Mulsow, 2006; Yu et al., 2010, 2012; Zimmerman et al., 2005). Response rates were not clearly reported in most (n=14) studies, while just three studies (two cross-sectional, one cohort) reported >80% response rate (Ebenegger et al., 2012; Lindsey and Colwell, 2003; Pagani et al., 2010).

Only one cross-sectional study (Ebenegger et al., 2012) reported using valid measures of both independent and dependent variables. Three studies (two cross-sectional, one cohort) reported the use of reliable measures for both independent and dependent variables (Ebenegger et al., 2012; Fagot and O'Brien, 1994; Lindsey and Colwell, 2003). Withdrawals, dropouts and non-completions (where not all participants provided full data) were generally poorly reported, with six studies (one cross-sectional, five cohort) not reporting these data (Christakis et al., 2004; Fagot and O'Brien, 1994; Foster and Watkins, 2010; Miller et al., 2007; Stevens and Mulsow, 2006; Zimmerman et al., 2005) and just three studies (two cross-sectional, one cohort) reported a high (>80%) completion rate (Conners-Burrow et al., 2011; Krejci et al., 2011; Manganello and Taylor, 2009).

Physical activity and psychosocial well-being

Figure 2 provides an illustration of associations between PA and each of the psychosocial well-being outcomes reported. One cohort and five cross-sectional studies reported on potential associations between measures of PA and psychosocial well-being. Hyperactivity/inattention (Ebenegger et al., 2012; Griffiths et al., 2010) and conduct problems (Griffiths et al., 2010; Yu et al., 2010, 2012) were the only indicators of psychosocial well-being investigated in more than one study, with inconsistent findings between studies. Moderate quality studies reported a lower proportion of null findings (25% vs. 88%) and a higher proportion of positive (25% vs. 12%) and inverse (50% vs. 0%) associations than methodologically weak studies. Independent *t*-tests revealed that studies rated as weak methodological quality were significantly less likely to find an association, either positive or inverse, than moderate quality studies ($p<0.001$). The one study using an objective measure of PA (Ebenegger et al., 2012) found positive associations, and the one study using parent report of sport participation found inverse associations (Griffiths et al., 2010), with measures of psychosocial well-being. However, the remaining studies which used active play or other active behaviors (such as walking, cycling) as PA indicators generally reported null associations (Fagot and O'Brien, 1994; Lindsey and Colwell, 2003; Yu et al., 2010, 2012). Three (Griffiths et al., 2010; Lindsey and Colwell, 2003; Yu et al., 2010) of the six studies investigated associations by sex; however, minimal differences were found.

INSERT FIGURE 2 ABOUT HERE

Evidence of dose-response

Only two cross-sectional studies investigated possible dose-response associations between indicators of PA and psychosocial well-being (Ebenegger et al., 2012; Yu et al., 2010). One study found that boys who engaged in exercise for up to one hour on a weekend day were at lower risk of developing conduct problems than boys who engaged in no exercise or more than one hour of exercise per day (Yu et al., 2010). The other study found that a mean increase of one unit on the hyperactivity/inattention scale (range 0-10) was associated with an increase of 9 counts per minute (cpm) as measured by accelerometry (Ebenegger et al., 2012).

Sedentary behaviors & psychosocial well-being

Figure 3 provides an illustration of associations between SB and each of the psychosocial well-being outcomes reported. Across the 15 studies which reported an indicator of SB, a total of 25 indicators of psychosocial well-being were investigated. The most commonly investigated psychosocial well-being indicators were hyperactivity/inattention in seven studies (Cheng et al., 2010; Christakis et al., 2004; Conners-Burrow et al., 2011; Ebenegger et al., 2012; Foster and Watkins, 2010; Griffiths et al., 2010; Tomopoulos et al., 2007), and aggressive behavior/aggression in seven studies (Conners-Burrow et al., 2011; Krejci et al., 2011; Manganello and Taylor, 2009; Martin et al., 2012; Mistry et al., 2007; Pagani et al., 2010; Tomopoulos et al., 2007). Overall findings for associations between SB and the psychosocial well-being indicators were inconclusive. Findings from cross-sectional and cohort studies were similar. SB studies assessed as moderate quality reported a greater proportion of inverse (14% vs. 4%), and a slightly lower proportion of positive (22% vs. 27%) and null findings (63% vs. 69%), than studies of weak quality. There was no difference in the likelihood of finding an association between weak and moderate quality studies ($p>0.05$). Only one study (Griffiths et al., 2010) investigated associations by sex with minimal differences between boys and girls.

INSERT FIGURE 3 ABOUT HERE

Evidence of dose-response

Five studies reported on dose-response associations between indicators of SB and psychosocial well-being. Those studies reported detrimental dose-response associations between higher levels of TV viewing and increased aggression (e.g. each additional hour of TV viewing was associated with a 16% increase in aggression (Manganello and Taylor, 2009)), attention problems (e.g. each additional hour of TV at 1 and 3 years was associated with a 9% increase in attentional problems at 7 years (Christakis et al., 2004)), externalizing behavior (e.g., each additional hour of media exposure was associated with children being two times more likely to exhibit aggressive behavior (Tomopoulos et al., 2007)) and poorer classroom engagement (each additional hour of TV viewing was associated with a 7% decrease in classroom engagement (Pagani et al., 2010)).

Discussion

This review synthesizes the literature on associations between PA and SB during early childhood with indicators of psychosocial well-being. There is a small but growing body of research in this area, evidenced by the increasing number of studies in recent years. Despite some individual studies reporting associations showing that increased PA or decreased SB may be supportive of children's psychosocial well-being, this review has found no consistent evidence across studies to support such conclusions.

Past reviews examining this literature in the early childhood population have reported that higher levels of PA and lower levels of SB (only TV viewing) were supportive of more positive psychosocial well-being during the early years (Leblanc et al., 2012; Timmons et al., 2012). However, the findings of this review, which employed broader inclusion criteria and a quality rating system, suggest such conclusions are premature. Although some evidence does exist to support the notion that increased PA and decreased SB are associated with more positive psychosocial well-being during early childhood, many studies found null associations, and a small number reported inverse associations. The only cohort study which reported on PA found no association between PA and indicators of psychosocial well-being, while findings from cohort studies investigating SB and psychosocial well-being were mixed between positive and null associations.

Reviews in other population groups have been more conclusive and provide evidence supporting associations between positive health behaviors and psychosocial well-being. For instance, a review of PA and psychological well-being in older adults concluded that there was substantial evidence supporting a positive association (McAuley and Rudolph, 1995). Reviews have also shown that PA may be protective against (Teychenne et al., 2008), and SB increase the risk of (Teychenne et al., 2010), depression in adults. Adolescent girls who engage in more screen time have been shown, across studies, to be at increased risk of depression and poorer psychological well-being (Costigan et al., 2013). Reviews investigating psychosocial well-being in children and adolescents have reported modest inverse associations between PA and depression (Janssen and Leblanc, 2010) and between electronic media use (primarily assessed as TV viewing) and both self-esteem and pro-social behavior (Tremblay et al., 2011). PA may also support enhanced self-esteem in children and adolescents (Ekeland et al., 2004). Collectively, this body of evidence suggests that indeed

these behaviors may be supportive of (in the case of PA), or detrimental to (in the case of SB), psychosocial well-being indicators. However, the evidence in the early childhood population is far from conclusive.

Findings in the early childhood population may be less conclusive due to the relatively small number of observational studies available. Assessment of psychosocial well-being during early childhood relies on proxy-report and is therefore more difficult to assess than if children were able to self-report. The lack of consistency between measures of PA and SB across studies, as well as the diversity of psychosocial well-being indicators reported, may also explain the lack of coherent findings. Further, the benefits of higher levels of PA and lower levels of SB may need time to accrue throughout childhood, during which time indicators of children's psychosocial well-being may also become more evident. No studies investigating PA and psychosocial well-being adjusted for any SB indicators, or vice versa, to determine the independence of the associations between children's behaviors and their psychosocial well-being independently of the other behavior. Additional cohort studies, which track children over longer periods of time, may be more potent in their ability to detect associations.

A further possible explanation for the relative lack of associations observed amongst children in this review relates to the lack of methodologically strong studies. There is clearly a lack of intervention studies in this area. RCTs, in particular, provide the gold standard of evidence to support associations between health behaviors and outcomes. Although one previous review identified two RCTs which investigated PA and psychosocial well-being (Timmons et al., 2012), neither of those studies met the inclusion criteria for this review (neither included a direct measure of PA (Lobo and Winsler, 2006; Porter, 1972)). A further two studies (Buss et al., 1980; Christakis and Zimmerman, 2007) identified in previous reviews were not included in this review as they included constructs of personality as the outcome rather than psychosocial well-being (Buss et al., 1980) and used content of television viewing rather than total volume as the predictor (Christakis and Zimmerman, 2007). The ability to draw robust conclusions relating to PA and SB during early childhood and their associations with psychosocial well-being would benefit from inclusion of high-quality studies, both observational and interventions. While the number of cohort studies is notable and encouraging, additional cohort studies using objective measures which are both valid and reliable may provide further insight into this field. However, such cohort studies can show

only temporal associations and not causality, thus RCT evidence is necessary. Standardizing measures across studies may also provide greater consistency and clarity between reported findings.

There were almost three times more studies investigating possible associations between SB and psychosocial well-being than there were investigating PA and psychosocial well-being. It is clear that further research should focus on PA. This imbalance may be reflective of research into health behaviors during early childhood as capturing SB is usually undertaken with survey measures while accurately capturing PA requires objective instruments such as accelerometry. Additionally, the majority of SB studies used TV viewing as their SB measure, with only one using an objective measure of overall SB (Ebenegger et al., 2012) and only two using total electronic media use as the measure (Griffiths et al., 2010; Tomopoulos et al., 2007). It is therefore necessary to draw on other measures of SB to provide a more comprehensive illustration of possible associations with psychosocial well-being. Given the plethora of electronic devices now available to engage young children in SBs, examination of associations of both objectively measured SB and electronic media use with psychosocial well-being is warranted.

A critical limitation of the published literature is the lack of objective measures of PA and SB as health behaviors. Only two studies, one measuring PA and SB, the other just measuring PA (Ebenegger et al., 2012; Fagot and O'Brien, 1994), used objective measures of the independent variables. The remainder used parent report of child behaviors, through survey, interview or diary. Contention exists over some aspects of accelerometry use with young children, such as which cut-points are most appropriate (Beets et al., 2011) or the best placement site (Ridgers and Fairclough, 2011). Nonetheless, accelerometers are a valid and reliable instrument with which to objectively measure the sporadic nature of young children's PA and overall SB (Cliff et al., 2009) which should ideally be incorporated into such studies. Nonetheless, they fail to capture the context and types of behaviors undertaken, and additional information on these characteristics of behaviors, which may be particularly important for SB, also needs to be collected. Concerns also exist around the use and reporting of valid and reliable measures used in each of the studies, with all but one study (Ebenegger et al., 2012) scoring weakly on that component of the quality assessment. Future studies should ensure they use valid and reliable instruments for both PA/SB and psychosocial well-being indicators. Additionally, insufficient studies investigated possible differences in

associations between boys and girls to justify drawing any possible conclusions. Further work in this area may be warranted to determine if boys' and girls' PA and SB behaviors differentially influence their psychosocial well-being.

Studies have used disparate measures of both the independent (PA/SB) and dependent variables. For instance, indicators of PA have included accelerometry (Ebenegger et al., 2012), play frequency (Flanders et al., 2009) and direct observation (Lindsey and Colwell, 2003) while SB measures have included TV hours per day (Cheng et al., 2010), accelerometry (Ebenegger et al., 2012), and the TV being generally on in the home (Martin et al., 2012). Likewise, indicators of child psychosocial well-being have included social skills (Conners-Burrow et al., 2011), physical aggression (Flanders et al., 2009) and attention problems (Martin et al., 2012), among others. Consequently, overall potential associations between PA and SB during early childhood with indicators of psychosocial well-being are unclear. Many of the psychosocial well-being indicators identified were only investigated in one study and as such, it was not possible to perform a meta-analysis on published findings. Further research, confirming existing results or providing methodologically sound evidence to the contrary, is necessary to clarify the association between children's health behaviors and their psychosocial well-being. Standardization of terms and definitions – e.g., emotionality vs. emotional symptoms vs. emotionally reactive; prosocial behavior vs. social skills; externalizing behavior vs. aggression – would also benefit this field and could provide greater ease in comparison between studies to support associations.

Relatively little dose-response evidence has been reported. Nonetheless, that which exists suggests that promoting increased participation in PA, and decreased TV viewing, may be warranted to support children's psychosocial well-being. However, with a lack of objective measures of children's behaviors, and only having dose-response evidence available for TV viewing amongst the SBs, substantial further evidence is required to support robust conclusions.

Strengths and limitations of the current review must be noted. The search strategy included a very broad range of possible terms used to capture constructs of psychosocial well-being and therefore a comprehensive range of possible outcomes is included. Despite the large number of resulting titles being screened by only one reviewer, it is likely that this review includes all possible papers as a reliability check by a second reviewer yielded no additional papers for inclusion. The search included only English language papers and therefore any papers which

may have been published in other languages were not included; however, that number is likely to be small.

Conclusion

Given the lack of evidence of associations of PA and SB with psychosocial well-being, findings of this review suggest that it may be premature to promote PA and SB behaviors in public health programs targeting the early childhood population only for their beneficial influence on psychosocial well-being. However, given the body of evidence in older children, adolescents and adults which is generally supportive of positive associations, further research is warranted in the early childhood population and promotion of these behaviors is important for other benefits in this population. Specifically, more high quality, methodologically sound studies are required to substantiate possible links between PA and SB with psychosocial well-being indicators during the early childhood period. Further, studies commencing in the early childhood period and investigating psychosocial well-being in later life are warranted to investigate longer term impacts of early life PA and SB on psychosocial well-being. It may be efficacious for PA and SB intervention studies to incorporate measures of psychosocial well-being in their data collection. Valid and reliable measures exist and can often be incorporated into planned survey instruments, adding additional significance to the project.

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Table 1: Search strategy used in PsycINFO

1.	“physical* activ*” or exercis* or "motor activit*" or "locomotor activit*" or play
2.	“sedentary behavio*” or sedentar* or television or TV or “screen time” or “electronic game*” or computer* or “small screen*” or e-game* or video* or "physical inactivity" or "screen based media" or gaming or "e game"
3.	infan* or pre-school* or preschool* or toddler* or "young child*" or “early childhood” or "early years"
4.	ADD or ADHD or "antisocial behavi*" or "anti-social behavi*" or anxi* or attention or "behavi* problem" or depress* or "emotional health" or "emotional skill*" or hyperactivity or inattention or "mental health" or "prosocial behavi*" or "psychological health" or "psychosocial health" or "self regulat*" or "self-regulat*" or "social behavi*" or "social competence" or "social skill*" or "social-emotional competence" or "well being" or "well-being"
5.	1 or 2
6.	3 and 4 and 5
7.	Limit 6 to years 1980-current and peer reviewed and English language and age groups: childhood (birth to 12 years) and human

Table 2: Summary of studies investigating physical activity and psychosocial well-being

Author; year; country	**Sample**	**PA measure**	**Psychosocial well-being measure & components**	**Association between PA & psychosocial well-being[a]**	**Dose response evidence**	**Confounders controlled for**	**Quality score/risk of bias**
Cross sectional studies							
Ebenegger et al; 2012; Switzerland	age: mean 5.2y (SD 0.6y); *n*=450 (47.8% boys)	ActiGraph accelerometry: MVPA (≥420 cpm); VPA (≥842 cpm)	French & German versions of SDQ, hyperactivity/ inattention subscales; parent report	MVPA with hyperactivity/inattention: + VPA with hyperactivity/ inattention: +	an increase of 1 in the score of hyperactivity/ inattention was associated with a mean increase of 9cpm	sex, age, sociolinguistic region, parental migrant status, educational level, preschool class (cluster) as random factor	Moderate/ moderate

Author; year; country	Sample	PA measure	Psychosocial well-being measure & components	Association between PA & psychosocial well-being[a]	Dose response evidence	Confounders controlled for	Quality score/risk of bias
Griffiths et al; 2010; UK	age: mean 5.2y; *n*=13470 (50.9% boys)	Participation in sport categorized as: 1. participates (1-5 d/wk) or 2. doesn't participate (<1 d/wk); parent report	SDQ, 5 scales: emotional symptoms, conduct problems, hyperactivity/ inattention problems, peer relationship problems, pro-social behavior; parent report	emotional symptoms: boys & girls: - conduct problems: boys & girls: - hyperactivity/ inattention problems: boys: 0; girls: - peer relationship problems: boys & girls: - pro-social behavior: boys & girls: 0	NR	child sex, ethnicity, longstanding illness; maternal employment status, education, SES, longstanding illness, emotional problems; household income, lone parent status, number of children in household	Moderate/ moderate

Author; year; country	Sample	PA measure	Psychosocial well-being measure & components	Association between PA & psychosocial well-being[a]	Dose response evidence	Confounders controlled for	Quality score/risk of bias
Lindsey and Colwell; 2003; USA	age: mean 60.4mo; *n*=44 (50.0% boys)	physical play (play contact or gross motor activity) @60.4mo; DO	emotional competence, regulation & understanding assessed by: Preschool Socio-affective Profile (teacher-rated emotional competence) Preschool Characteristics Questionnaire (mother-rated emotion regulation) emotion understanding interview (with child)	teacher-rated emotional competence: boys: +; girls: 0 mother-rated emotion regulation: boys & girls: 0 child emotion understanding: boys & girls: 0	NR	NR	Weak/ high

Author; year; country	Sample	PA measure	Psychosocial well-being measure & components	Association between PA & psychosocial well-being[a]	Dose response evidence	Confounders controlled for	Quality score/risk of bias
Yu et al; 2010; Australia	age: 4-5y; *n*=1414 (51.6% boys)	TUD: walking, bike riding, exercise; all three combined as indicator of MVPA; parent report	SDQ (conduct subscale, 5 items); parent report	wkday *walk:* boys & girls: 0 *ride:* boys: +; girls: 0 *exercise:* >0h and ≤1h/day: boys & girls: 0; >1h and ≤24h/day: boys & girls: 0 wkend day *walk:* boys & girls: 0 *ride:* boys & girls: 0 *exercise:*>0h and ≤1h/day: boys & girls: 0; >1h and ≤2h/day: boys & girls: 0; >2h and ≤24h/day: boys: + (decreased risk); girls: 0	boys who engaged in exercise for up to 1 h on a wkend day were at 11%, 70% and 134% lower risk of developing conduct problems than boys who engaged in exercise for no time, 1–2 h and > 2 h respectively (no association for girls)	NR	Weak/ high

Author; year; country	Sample	PA measure	Psychosocial well-being measure & components	Association between PA & psychosocial well-being[a]	Dose response evidence	Confounders controlled for	Quality score/risk of bias
Yu et al; 2012; Australia	age: 4-5y; *n*=4936 (50.9% boys)	TUD: walking, bike riding, exercise; all three combined as indicator of MVPA; parent report	SDQ (conduct subscale, 5 items); parent report	bike riding with risk of developing conduct problems: + other PA indicators had no association with risk of developing conduct problems or risk of developing conduct problems interacting with day type (wk/wkend days)/sex	NR	NR	Weak/ high

Author; year; country	Sample	PA measure	Psychosocial well-being measure & components	Association between PA & psychosocial well-being[a]	Dose response evidence	Confounders controlled for	Quality score/risk of bias
Cohort Studies							
Fagot and O'Brien; 1994; USA	group 1: age: 18mo @ baseline, 27mo @ f/u; *n*=101 (50.5% boys) group 2: age: 12mo @ baseline; 18mo @ f/u; *n*=83 (53.0% boys)	large motor play (DO at home & play-group)	CBC (3 scores: total problem behaviors, externalizing problems, internalizing problems); parent report	observed large motor activity (at home & at play-group) (both groups): boys & girls: total problem behaviors: 0 externalizing problems: 0 internalizing problems: 0	NR	NR	Weak/ high

Notes: [a]where unadjusted and adjusted models are reported in the paper, only those results from the adjusted models are included here.

Abbreviations: 0: null association; -: inverse association; +: positive association; assn.: association; CBC: Child Behavior Checklist; cpm: counts per minute; DO: direct observation; d: day; f/u: follow-up; h: hour; mo: month; MVPA: moderate- to vigorous-intensity physical activity; NR:

not reported; PA: physical activity; SDQ: Strengths and Difficulties Questionnaire; SD: standard deviation; TUD: time use diary; VPA: vigorous-intensity physical activity; wk: week; y: year.

Table 3: Summary of studies investigating sedentary behavior and psychosocial well-being

Author; year; country	**Sample**	**SB measure**	**Psychosocial well-being measure & components**	**Association between SB & psychosocial well-being[a]**	**Dose response evidence**	**Confounders controlled for**	**Quality score/risk of bias**
Cross-sectional studies							
Conners-Burrow et al; 2011; USA	age: mean 62.5 mo (SD 4.1mo) ; *n*=95 (approx. 50% boys)	TV h/d categorical: <1h, 1-2hs, 2-3hs, >3hs; maternal report	problem behavior: Achenbach System of Empirically-Based Assessment, 2 subscales - hyperactive & aggressive social skills: Social Skills Scale (developed by the Head Start Family and Child Experiences Survey), 12 items All preschool teacher report	hyperactive behavior: 0 aggression: 0 social skills: 0	NR	child sex, maternal education, minority status	Weak/high

Author; year; country	Sample	SB measure	Psychosocial well-being measure & components	Association between SB & psychosocial well-being[a]	Dose response evidence	Confounders controlled for	Quality score/risk of bias
Ebenegger et al; 2012; Switzerland	age: mean 5.2y (SD 0.6y); *n*=450 (47.8% boys)	objective SB: ActiGraph (time in SB categorized as ≤25 cpm) TV min/day; parent report	French and German versions of SDQ hyperactivity/ inattention subscale; parent report	objective SB: - TV viewing: +	NR	sex, age, sociolinguistic region, parental migrant status, educational level, preschool class (cluster)	Moderate/ moderate

Author; year; country	Sample	SB measure	Psychosocial well-being measure & components	Association between SB & psychosocial well-being[a]	Dose response evidence	Confounders controlled for	Quality score/risk of bias
Griffiths et al; 2010; UK	age: mean 5.2y; *n*=13470 (50.9% boys)	screen-time (TV/video/DVD, computer, e-games); h/d categorized as ≥2 h/day or <2 h/day; parent report	SDQ to investigate emotional symptoms, conduct problems, hyperactivity/ inattention problems, peer relationship problems, pro-social behavior; parent report	emotional symptoms: boys: 0; girls: + conduct problems: boys: 0; girls: + hyperactivity/ inattention problems: boys: 0; girls: 0 peer relationship problems: boys: 0; girls: 0 pro-social behavior: boys: 0; girls: 0	NR	child sex, ethnicity, longstanding illness; maternal employment status, education, SES, longstanding illness, emotional problems; household income, lone parent status, number of children in household	Moderate/ moderate

Author; year; country	Sample	SB measure	Psychosocial well-being measure & components	Association between SB & psychosocial well-being[a]	Dose response evidence	Confounders controlled for	Quality score/risk of bias
Krejci et al; 2011; Czech Republic & Japan	Czech: age: mean 4.6y; *n*=497 (51.7% boys) Japanese: age: mean 3.79ys; *n*=599 (47.6% boys)	video game use (frequency per wk); parent and child survey	two items assessing anger & depression as indicators of mental health; parent report	anger: Czech: 0 Japanese: + depression: Czech: 0 Japanese: -	NR	NR	Weak/high

Author; year; country	Sample	SB measure	Psychosocial well-being measure & components	Association between SB & psychosocial well-being[a]	Dose response evidence	Confounders controlled for	Quality score/risk of bias
Manganello et al; 2009; USA	age: mean 36mo; *n*=3128 (47.1% boys)	direct child TV exposure (h/day) & household TV use (h TV on in household/ day, excluding direct exposure); maternal report	CBC, aggressive subscale; maternal report	TV exposure: + household TV use: +	predicted aggression score increased by 16% for each additional h a child directly watched TV and by 9% for each additional h of household TV use	child sex; maternal age, nativity, race, education, work h/wk, relationship status; paternal age, education; household characteristics: mother & father married at child's birth, income, food stamp usage, additional adults & children in home	Moderate/ moderate
Miller et al; 2007; USA	age: mean 4.31y (SD 0.51y); *n*=170 (61.8% boys)	TV h/d; parental semi-structured interview	18 ADHD behaviors listed in DSM-IV; parent & teacher survey	parent report of ADHD symptoms: 0 teacher report of ADHD symptoms: +	NR	child sex, child age, SES	Weak/high

Author; year; country	Sample	SB measure	Psychosocial well-being measure & components	Association between SB & psychosocial well-being[a]	Dose response evidence	Confounders controlled for	Quality score/risk of bias
Cohort studies							
Cheng et al; 2010, Japan	age: 4mo @ baseline; 30 mo @ final f/u; *n*=302 (50.7% boys)	TV h/d as continuous data; categorized into <1, 1-3, 3-4, >=4 h/d; data collected at 18 & 30 mo; maternal report	Japanese version of the SDQ: conduct & peer problems, hyperactivity-inattention, emotional symptoms, peer problems, prosocial behavior; examined @30 mo; parent report	TV viewing @18mo: emotional symptoms: 0 conduct problems: 0 hyperactivity-inattention: + peer-problems: 0 prosocial behavior: - TV viewing @30 mo: emotional symptoms: 0 conduct problems: 0 hyperactivity-inattention: + peer-problems: 0 prosocial behavior: 0	evidence of increasing TV associated with detrimental outcomes but no clear dose-response associated reported	child sex, birth weight, gestational age; maternal education, stimulation level; number of children, annual household income	Moderate/ moderate

Author; year; country	Sample	SB measure	Psychosocial well-being measure & components	Association between SB & psychosocial well-being[a]	Dose response evidence	Confounders controlled for	Quality score/risk of bias
Christakis et al; 2004; USA	age: 12mo @ baseline; 7y @ final f/u; *n*=1278 @ 12mo; *n*=1345 @ 3y (approx. 50% boys)	TV h/d@12mo & 3y; maternal report	hyperactivity subscale of Behavioral Problems Index, 5 items to indicate attention problems@7y; maternal report	TV viewing @1y: + TV viewing @3ys: +	1h increase in number of h of TV watched @1y and @3y of age associated with a 9% increase in the odds of having attentional problems @7ys	Child race/ethnicity, sex, gestational age; maternal alcohol and tobacco use during pregnancy, number of children & parents in household, urban versus rural residence, index year	Weak/high

Author; year; country	Sample	SB measure	Psychosocial well-being measure & components	Association between SB & psychosocial well-being[a]	Dose response evidence	Confounders controlled for	Quality score/risk of bias
Foster et al; 2010; USA	age: 1-3y @ baseline; 7y @ final f/u; *n*=1039 @ 1y, *n*=1159@ 3y (approx. 50% boys)	TV h/d; continuous h & also categorized into hrly increments from 0 to >7hs; maternal report	hyperactivity subscale of Behavioral Problems Index, 5 items to indicate attention problems@7y; maternal report	continuous TV @1y: 0 continuous TV @3y: 0 hrly viewing categories: all fully adjusted models: 0	an additional h of daily television increased the probability of attention problems by 0.5%	child sex, age, race, gestational age; maternal alcohol & tobacco consumption during pregnancy, age, education, depression, self-esteem, academic achievement; number of children in household, presence of two parents, cognitive stimulation and emotional support scores, urbanicity, family income	Weak/high

Author; year; country	Sample	SB measure	Psychosocial well-being measure & components	Association between SB & psychosocial well-being[a]	Dose response evidence	Confounders controlled for	Quality score/risk of bias
Martin et al; 2012; USA	age: 2.5y @ baseline; 5y @ f/u; *n*=842 (53.0% male)	TV generally on in home (yes/no) @2.5y; maternal report	CBC: attention problems (8 items); aggression (13 items); anxiety/depression (14 items); maternal report 'gift wrap' task: delayed gratification; administered to child administered @5y	attention problems: + aggression: + anxiety/depression: 0 delayed gratification: 0	NR	child age, sex; maternal education, age, maternal race/ ethnicity, marital status; income per capita, family size	Moderate/ moderate
Mistry et al; 2007; USA	age: 30-33mo @ baseline; 5.5y @ f/u; *n*=2707 (49.0% boys)	TV h/d: categorized as "early TV exposure" (>2 h/day at 30-33mo only), "concurrent exposure" (>2 h/day at 5.5ys only), "sustained exposure" (>2 h/day at both	CBC, 5 scales: emotionally reactive (9 items), anxious or depressed (8 items), sleep problems (7 items), attention problems (5 items), and aggressive behavior (19 items). Attention problems & aggressive behavior were summed to give	CBC: early exposure: emotionally reactive: -; anxious or depressed: 0; sleep problems: 0; attention problems: 0; aggressive behavior: 0; externalizing: 0 concurrent exposure: emotionally reactive: 0; anxious or depressed: 0; sleep problems: 0; attention problems: 0; aggressive behavior: 0;	NR	Child sex; maternal education, age at child's birth, marital status, employment race, ethnicity, depressive symptoms; household income,	Moderate/ moderate

Author; year; country	Sample	SB measure	Psychosocial well-being measure & components	Association between SB & psychosocial well-being[a]	Dose response evidence	Confounders controlled for	Quality score/risk of bias
		30-33mo & 5.5ys); parent report	additional externalizing scale. Social Skills Rating System, 4 subscales: co-operation, assertion, responsibility, self-control (10 items each) All parent report @5.5y	externalizing: 0 sustained exposure: emotionally reactive: 0; anxious or depressed: 0; sleep problems: +; attention problems: +; aggressive behavior: +; externalizing: + Social Skills Rating System: early exposure: cooperation: 0; assertion: 0; self-control: 0; responsibility: 0; total social skills: 0 concurrent exposure: cooperation: -; assertion: -; self-control: -; responsibility: 0; total social skills: - sustained exposure: co-operation: 0; assertion: 0; self-control: -; responsibility: 0; total social skills: 0		parity, parental involvement	

Author; year; country	Sample	SB measure	Psychosocial well-being measure & components	Association between SB & psychosocial well-being[a]	Dose response evidence	Confounders controlled for	Quality score/risk of bias
Pagani et al; 2010; Canada	age: 17mo @ baseline; 29mo, 53mo, 122mo @ f/u; *n*=1314 (sex distribution NR)	TV h/d @29mo; parent report	Social Behavior Questionnaire (emotional distress: 6 items; reactive aggression: 4 items; victimization: 3 items) Classroom engagement scale (11 items) All teacher report @10ys	classroom engagement: - victimization: + emotional distress & reactive aggression NR	Every additional h of early childhood TV viewing corresponded to a 7% unit decrease in classroom engagement	child sex, temperament problems, hours of continuous sleep, BMI; maternal education, family makeup, parent-reported family functioning	Moderate/ moderate
Stevens and Mulsow; 2006; USA	age: NR – children in kindergarten @ baseline; first grade @ f/u; *n*=5000 (sex distribution NR)	TV h/d; parent report @kinder	Social Rating Scale (derived from the Social Skills Rating Scale: Elementary Scale A) as indicator of ADHD @ first grade; teacher report	symptoms of ADHD: 0	NR	limits on watching TV, parental involvement, with child, SES	Weak/high

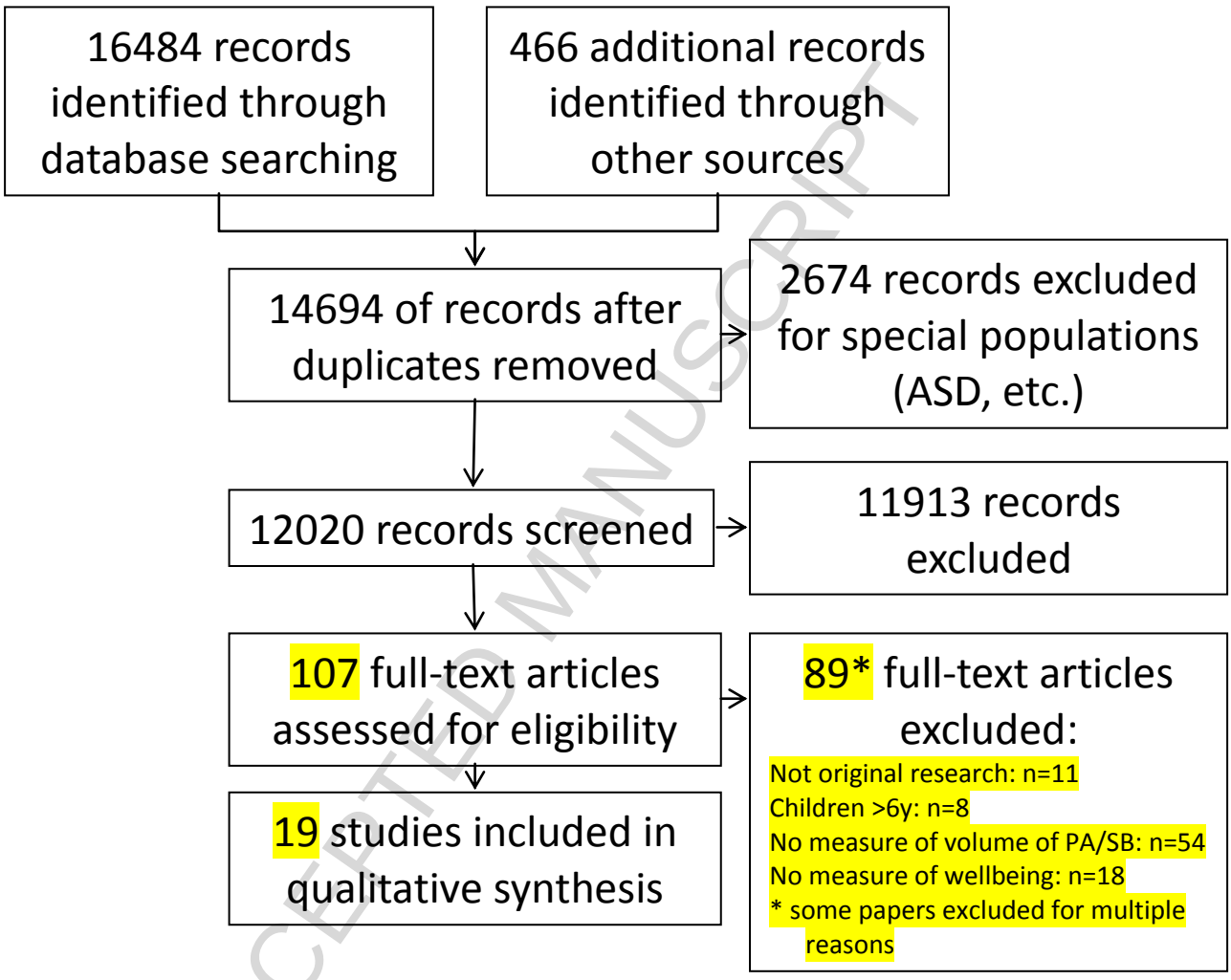
Author; year; country	Sample	SB measure	Psychosocial well-being measure & components	Association between SB & psychosocial well-being[a]	Dose response evidence	Confounders controlled for	Quality score/risk of bias
Tomopoulos et al; 2007; USA	age: 21mo @ baseline; 33mo @ f/u; *n*=99 (sex distribution NR)	media exposure (TV, videos/ movies, computer/ video games) h/d; caregiver 24h recall diary administered though interview	CBC, 5 scales: aggressive behavior, attention problems, attention deficit/hyperactivity problems, oppositional defiant problems, externalizing problems to assess inattention, aggression and hyperactivity @33mo; interview with caregiver	media exposure @21mo: aggressive behavior: +; attention problems: 0; oppositional defiant problems: 0; attention deficit/hyperactivity problems: 0; externalizing problems: + media exposure @33mo: aggressive behavior: 0; attention problems: 0; oppositional defiant problems: 0; attention deficit/hyperactivity problems: 0; externalizing problems: 0	children were 2 and 1.6 times more likely to exhibit aggressive behavior & externalizing problems, respectively, per h increase in media exposure time	child age, sex, firstborn status, enrolment in day care, perceived difficult child temperament; maternal age, education, country of origin, language spoken, depressive symptoms; household composition, parent-child reading activities	Weak/high

Author; year; country	Sample	SB measure	Psychosocial well-being measure & components	Association between SB & psychosocial well-being[a]	Dose response evidence	Confounders controlled for	Quality score/risk of bias
Zimmerman et al; 2005; USA	age: 4y @ baseline; f/u at 6-11y; *n*=1266 (51.0% boys)	TV h/d@4y; maternal report	characterization of child as a bully @ ages 6mo-1y (single item); maternal report	being a bully: +	NR	child age, sex race/ethnicity ; parental income, education	Weak/high

Notes: [a]where unadjusted and adjusted models are reported in the paper, only those results from the adjusted models are included here

Abbreviations: 0: null association; -: inverse association; +: positive association; ADHD: attention deficit hyperactivity disorder; BMI: Body Mass Index; CBC: Child Behavior Checklist; cpm: counts per minute; d: day; DSM-IV: Diagnostic and Statistical Manual of Mental Disorders: Fourth Edition; DVD: digital video disc; e-games: electronic games; f/u: follow-up; h: hour; min: minutes; mo: month; NR: not reported; SB: sedentary behavior; SDQ: Strengths and Difficulties Questionnaire; SD: standard deviation; SES: Socio-economic Status; TV: television; wk: week; y: year.

Figure 1: Flow of records through the systematic review



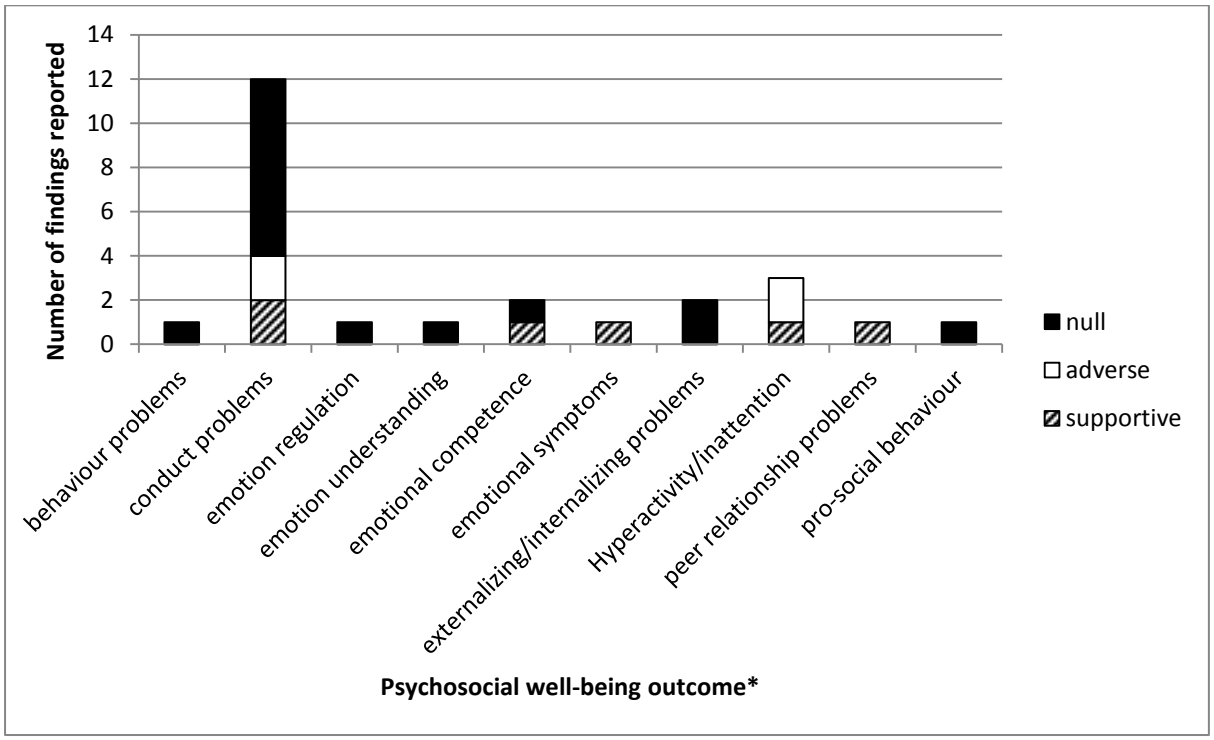


Figure 2: physical activity studies reporting null, adverse and supportive associations with improved psychosocial well-being outcomes

*Note: some studies reported on multiple indicators of PA with the psychosocial well-being outcomes reported

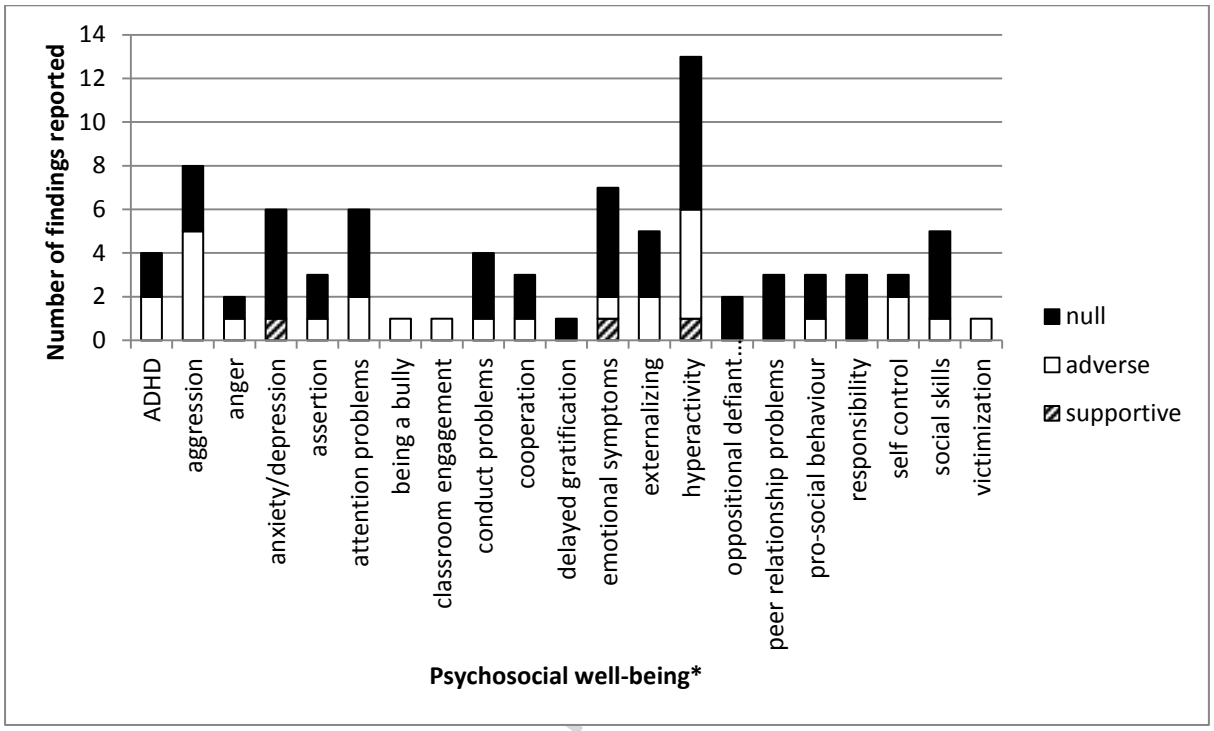


Figure 3: sedentary behaviour studies reporting null, adverse and supportive associations with improved psychosocial well-being outcomes

*Note: some studies reported on multiple indicators of SB with the psychosocial well-being outcomes reported

Highlights

- The first review to comprehensively evaluate early childhood PA/SB with psychosocial well-being
- Each psychosocial well-being indicator was investigated in a minimal number of studies
- Multiple and disparate indicators of PA/SB were used
- No studies of strong methodological quality nor any RCTs were identified
- PA/SB during early childhood show no clear association with psychosocial well-being