Evidence Portfolio – Youth Subcommittee, Question 3

In children and adolescents, is sedentary behavior related to health outcomes?

a. What is the relationship between sedentary behavior and cardiometabolic health?
b. What is the relationship between sedentary behavior and adiposity/weight status?
c. What is the relationship between sedentary behavior and bone health?
d. Are there dose-response relationships? If so, what are the shapes of those relationships?
e. Do the relationships vary by age, sex, race/ethnicity, weight status or socio-economic status?

Source of Evidence: Original Research, Existing Systematic Reviews, and Meta-Analyses

Conclusion Statements and Grades

Limited evidence suggests that greater time spent in sedentary behavior is related to poorer health outcomes in children and adolescents. **PAGAC Grade: Limited.**

Limited evidence suggests that greater time spent in sedentary behavior is related to poorer cardiometabolic health; the evidence is somewhat stronger for television viewing or screen time than for total sedentary time. **PAGAC Grade: Limited.**

Limited evidence suggests that greater time spent in sedentary behavior is related to higher weight status or adiposity in children and adolescents; the evidence is somewhat stronger for television viewing or screen time than for total sedentary time. **PAGAC Grade: Limited.**

Limited evidence suggests that sedentary behavior is not related to bone health in children and adolescents. **PAGAC Grade: Limited.**

Insufficient evidence is available to determine whether a dose-response relationship exists between greater time spent in sedentary behavior and poorer health outcomes in children and adolescents. **PAGAC Grade: Not assignable.**

Insufficient evidence is available to determine whether the relationship between sedentary behavior and health outcomes in youth is moderated by age, sex, race/ethnicity, or socioeconomic status. **PAGAC Grade: Not assignable.**

Description of the Evidence

An initial search for systematic reviews, meta-analyses, pooled analyses, and reports did not identify sufficient literature to fully answer the research question as determined by the Youth Subcommittee. A supplementary search for original research was conducted to capture literature related to sedentary behavior and bone health.

Existing Systematic Reviews and Meta-Analysis

CARDIOMETABOLIC RISK FACTORS

Overview

A total of 4 existing reviews that examined the association between sedentary behavior and cardiometabolic risk factors were included: 1 meta-analysis[1] and 3 systematic reviews.[2-4] The reviews were published between 2011 and 2016.

The meta-analysis included 24 studies and covered a timeframe from inception to November 2015.[1]

The systematic reviews included a range of 27–232 studies and covered the following timeframes: February 2010 to December 2014[2]; 1989 to April 2010[3]; and inception to February 2010.[4]

Exposures

All the included reviews examined sedentary behavior. The meta-analysis by Cliff et al[1] assessed the total volume or patterns (i.e., breaks and bouts) of sedentary behavior measured objectively for observational studies, and interventions specifically focused on decreasing sedentary behavior for experimental studies. The 3 systematic reviews[2-4] assessed self-reported or objectively measured sedentary time, primarily screen time.

Outcomes

All the included reviews examined individual and/or clustered cardiometabolic risk factors, including insulin/glucose levels, lipid profile, and blood pressure.

WEIGHT STATUS/ADIPOSITY

Overview

A total of 8 existing reviews that examined the association between sedentary behavior and weight status/adiposity were included: 3 meta-analyses[1, 5, 6] and 5 systematic reviews.[2-4, 7, 8] The reviews were published between 2011 and 2016.

The meta-analyses included a range of 14 to 67 studies and covered the following timeframes: 1980 to March 2015[5]; and inception to 2015.[1, 6]

The systematic reviews included a range of 4 to 232 studies and covered the following timeframes: February 2010 to December 2014[2]; 1989 to April 2010[3]; inception to May 2011[7]; 1990 to June 2012[8]; and Inception to February 2010.[4]

Exposures

All the included reviews examined sedentary behavior. The meta-analysis by Azevedo et al[5] compared the effect of single vs. multi-component interventions to reduce sedentary behavior. Cliff et al[1] assessed the total volume or patterns (i.e., breaks and bouts) of sedentary behavior measured objectively for observational studies, and interventions specifically focused on decreasing sedentary behavior for experimental studies. Four reviews assessed primarily screen time/TV watching.[2-4, 6] Pate et al[8] examined objectively measured sedentary time.

Outcomes

All the included reviews examined adiposity/weight status. Measures included body mass index, percentage of body fat, and waist circumference.

Original Research

BONE HEALTH

Overview

A total of 4 prospective cohort studies[9-12] that examined the relationship between sedentary behavior and bone health were included as sources of evidence. The articles were published between 2013 and 2017.

The analytical sample size ranged from 169[11] to 602.[10] Of the studies that reported location, 2 were conducted in Estonia[11, 12] and 1 was conducted in Denmark.[10]

Exposures

The included studies examined sedentary activity measured with an accelerometer. The 4 studies used the Evenson accelerometer cutoff points that define sedentary activity as ≤ 100 accelerometer counts per minute.

Outcomes

Three of the included studies examined bone health outcomes, including bone mineral content, bone mineral density, and bone area using dual x-ray absorptiometry.[10-12] Gabel et al[9] examined bone strength-related outcomes using high-resolution peripheral quantitative computed tomography (HR-pQCT) at distal tibia and radius.

Populations Analyzed

The table below lists the populations analyzed in each article.

Table 1. Populations Analyzed by All Sources of Evidence

	Sex	Race/ Ethnicity	Age	Socio-economic Status	Weight Status
Azevedo, 2016			Children and youth 0–5, 5–12, 12–17		Overweight and obese, mixed weight
Carson, 2016			Children and youth 5–17		
Chinapaw, 2011			Children and youth 3–17		
Cliff, 2016			Children and youth 2–18		
Gabel, 2017			Children and youth 9–20		
Heidemann, 2013	Male, Female		Schoolchildren 2nd–4th grade (7–12 years)		
Ivuškāns, 2015	Male		Youth 11–13		
LeBlanc, 2012			Children <1, 1–3, 3–5		
Pate, 2013			Children and youth 5–18		
Tremblay, 2011			Children and youth 2–19		
Vaitkeviciute, 2014	Male		12 years at baseline		Underweight, normal/ healthy weight, overweight, obese
Wu, 2016			Children and youth <6, 6–17, >18		

Supporting Evidence

Existing Systematic Reviews and Meta-Analysis

Table 2. Existing Systematic Reviews and Meta-Analysis Individual Evidence Summary Tables

<table>
<tr><th colspan="2">Weight Status/Adiposity</th></tr>
<tr><td colspan="2">Meta-Analysis
Citation: Azevedo LB, Ling J, Soos I, Robalino S, Ells L. The effectiveness of sedentary behaviour interventions for reducing body mass index in children and adolescents: systematic review and meta-analysis. Obes Rev. 2016;17(7):623-635. doi:10.1111/obr.12414.</td></tr>
<tr><td>Purpose: To summarize and compare the effect of interventions that target sedentary behavior (e.g., TV viewing, video gaming) on body mass index (BMI) or BMI z-score in children (0 to 17 years old of any weight status), assessed using either a randomized or nonrandomized controlled trial.</td><td rowspan="4">Abstract: Intervention studies have been undertaken to reduce sedentary behaviour (SB) and thereby potentially ameliorate unhealthy weight gain in children and adolescents. We synthesised evidence and quantified the effects of SB interventions (single or multiple components) on body mass index (BMI) or BMI z-score in this population. Publications up to March 2015 were located through electronic searches. Inclusion criteria were interventions targeting SB in children that had a control group and objective measures of weight and height. Mean change in BMI or BMI z-score from baseline to post-intervention were quantified for intervention and control groups and meta-analyzed using a random effects model. The pooled mean reduction in BMI and BMI z-score was significant but very small (standardized mean difference = -0.060, 95% confidence interval: -0.098 to -0.022). However, the pooled estimate was substantially greater for an overweight or obese population (standardized mean difference = -0.255, 95% confidence interval: -0.400 to -0.109). Multicomponent interventions (SB and other behaviours) delivered to children from 5 to 12 years old in a non-educational setting appear to favour BMI reduction. In summary, SB interventions are associated with very small improvement in BMI in mixed-weight populations. However, SB interventions should be part of multicomponent interventions for treating obese children. (c) 2016 World Obesity.</td></tr>
<tr><td>Timeframe: 1980–2015</td></tr>
<tr><td>Total # of Studies: 67</td></tr>
<tr><td>Exposure Definition: Sedentary behavior (SB): the intervention had to target activities undertaken while sitting or lying down, such as screen-based activities. Included both single (SB only) or multi-component intervention (targeted other behaviors such as PA or diet as well as SB). Subgroups: intervention type (SB, SB+PA, SB + other behaviors).
Measures Steps: No
Measures Bouts: No
Examines HIIT: No</td></tr>
<tr><td>Outcomes Addressed: Standardized mean difference for BMI and BMI z-score.
Examine Cardiorespiratory Fitness as Outcome: No</td><td></td></tr>
<tr><td>Populations Analyzed: Youth 0–17 years (0–5, 5–12, 12–17); overweight and obese; mixed weight</td><td>Author-Stated Funding Source: This study was partially funded by Teesside University and Fuse, the Centre for Translational Research in Public Health.</td></tr>
</table>

<table>
<tr><th colspan="2">Cardiometabolic Risk Factors, Weight Status/Adiposity</th></tr>
<tr><td colspan="2">Systematic Review
Citation: Carson V, Hunter S, Kuzik N, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth: an update. Appl Physiol Nutr Metab. 2016;41(6 suppl 3):S240-S265. doi:10.1139/apnm-2015-0630.</td></tr>
<tr><td>Purpose: To update the Tremblay, et al. (2011) review by examining all new available evidence on the relationships between objectively and subjectively measured sedentary behavior and health indicators in children and youth ages 5–17; also aimed to determine which types (e.g., TV, computer, homework) and doses (e.g., total amount, interruptions, bout durations) of sedentary behavior were associated with health indicators.</td><td rowspan="4">Abstract: This systematic review is an update examining the relationships between objectively and subjectively measured sedentary behaviour and health indicators in children and youth aged 5-17 years. EMBASE, PsycINFO, and Medline were searched in December 2014, and date limits were imposed (>/=February 2010). Included studies were peer-reviewed and met the a priori-determined population (apparently healthy children and youth, mean age: 5-17 years), intervention (durations, patterns, and types of sedentary behaviours), comparator (various durations, patterns, and types of sedentary behaviours), and outcome (critical: body composition, metabolic syndrome/cardiovascular disease risk factors, behavioural conduct/pro-social behaviour, academic achievement; important: fitness, self-esteem) study criteria. Quality of evidence by outcome was assessed using the Grading of Recommendations Assessment, Development, and Evaluation framework. Due to heterogeneity, a narrative analysis was conducted. A total of 235 studies (194 unique samples) were included representing 1 657 064 unique participants from 71 different countries. Higher durations/frequencies of screen time and television (TV) viewing were associated with unfavourable body composition. Higher duration/frequency of TV viewing was also associated with higher clustered cardiometabolic risk scores. Higher durations of TV viewing and video game use were associated with unfavourable behavioural conduct/pro-social behaviour. Higher durations of reading and doing homework were associated with higher academic achievement. Higher duration of screen time was associated with lower fitness. Higher durations of screen time and computer use were associated with lower self-esteem. Evidence ranged from "very low" to "moderate" quality. Higher quality studies using reliable and valid sedentary behaviour measures should confirm this largely observational evidence.</td></tr>
<tr><td>Timeframe: 2010–2014</td></tr>
<tr><td>Total # of Studies: 194</td></tr>
<tr><td>Exposure Definition: Objectively or subjectively measured sedentary behavior (SB), primarily screen time. Studies were required to have a measure of SB rather than a measure of the absence of PA. For experimental studies, interventions had to target sedentary behavior only.
Measures Steps: No
Measures Bouts: No
Examines HIIT: No</td></tr>
<tr><td>Outcomes Addressed: Body composition: body mass index, waist circumference, sum of skinfolds. Metabolic syndrome/cardiovascular disease risk factors: blood pressure, cholesterol, insulin. Health indicators related to fitness: cardiorespiratory fitness, muscular strength/ endurance, flexibility.
Examine Cardiorespiratory Fitness as Outcome: Yes</td></tr>
<tr><td>Populations Analyzed: Youth 5–17</td><td>Author-Stated Funding Source: Canadian Society for Exercise Physiology, Children’s Hospital of Eastern Ontario Research Institute, Conference Board of Canada, and the Public Applied Physiology, Nutrition, and Metabolism Health Agency of Canada.</td></tr>
</table>

<table>
<tr><th colspan="2">Cardiometabolic Risk Factors, Weight Status/Adiposity</th></tr>
<tr><td colspan="2">Systematic Review
Citation: Chinapaw MJ, Proper KI, Brug J, van Mechelen W, Singh AS. Relationship between young peoples' sedentary behaviour and biomedical health indicators: a systematic review of prospective studies. Obes Rev. 2011;12(7):e621-32. doi:10.1111/j.1467-789X.2011.00865.x.</td></tr>
<tr><td>Purpose: To appraise the quality and summarize and integrate the results of the available prospective studies examining the relationship between sedentary behaviors and various health outcomes in youth.</td><td rowspan="4">Abstract: The aim of this systematic review was to describe the prospective relationship between childhood sedentary behaviour and health indicators. We identified prospective studies from searches in PubMed, EMBASE, PsycInfo and Cochrane, from January 1989 through April 2010. Two reviewers independently screened the titles and abstracts for eligibility, rated the methodological quality of the studies, and extracted data. We identified 31 papers, examining 27 different cohorts. The quality score of the studies ranged from 38 to 88%. Nine studies were scored as high quality. According to the best evidence synthesis we found insufficient evidence for a longitudinal positive relationship between 'sedentary time'- mainly TV viewing - and body mass index (BMI) and more specific indicators of fat mass. One high quality and two low quality studies found a significant inverse relationship between sedentary time - mainly TV viewing - and aerobic fitness, leading to moderate evidence for this inverse relationship. There was insufficient evidence for a longitudinal relationship between sedentary time and blood pressure, blood lipids or bone mass. Our systematic review suggests that there is moderate evidence for a longitudinal inverse relationship between screen time and aerobic fitness during childhood. Thus there is evidence to limit screen time in young people in order to prevent low levels of fitness. The possible detrimental health effects of prolonged or excessive sitting on other health indicators needs further study.</td></tr>
<tr><td>Timeframe: 1989–2010</td></tr>
<tr><td>Total # of Studies: 27</td></tr>
<tr><td>Exposure Definition: Sedentary behavior (both self reported and objectively measured): TV viewing, screen time, video games, computer use.
Measures Steps: No
Measures Bouts: No
Examines HIIT: No</td></tr>
<tr><td>Outcomes Addressed: Body mass index z-score, waist circumference, fat percentage, skin folds, cardiorespiratory fitness, blood pressure, blood lipids, and bone mass.
Examine Cardiorespiratory Fitness as Outcome: Yes</td></tr>
<tr><td>Populations Analyzed: Youth 3–17 years</td><td>Author-Stated Funding Source: Not reported.</td></tr>
</table>

<table>
<tr><th colspan="2">Cardiometabolic Risk Factors, Weight Status/Adiposity</th></tr>
<tr><td colspan="2">Meta-Analysis
Citation: Cliff DP, Hesketh KD, Vella SA, et al. Objectively measured sedentary behaviour and health and development in children and adolescents: systematic review and meta-analysis. Obes Rev. 2016;17(4):330-44. doi: 10.1111/obr.12371.</td></tr>
<tr><td>Purpose: To determine whether the total volume and patterns (i.e., breaks and bouts) of objectively measured sedentary behavior were associated with adverse health outcomes in young people, independent of moderate-intensity to vigorous-intensity PA.</td><td rowspan="5">Abstract: Sedentary behaviour has emerged as a unique determinant of health in adults. Studies in children and adolescents have been less consistent. We reviewed the evidence to determine if the total volume and patterns (i.e. breaks and bouts) of objectively measured sedentary behaviour were associated with adverse health outcomes in young people, independent of moderate-intensity to vigorous-intensity physical activity. Four electronic databases (EMBASE MEDLINE, Ovid EMBASE, PubMed and Scopus) were searched (up to 12 November 2015) to retrieve studies among 2- to 18-year-olds, which used cross-sectional, longitudinal or experimental designs, and examined associations with health outcomes (adiposity, cardio-metabolic, fitness, respiratory, bone/musculoskeletal, psychosocial, cognition/academic achievement, gross motor development and other outcomes). Based on 88 eligible observational studies, level of evidence grading and quantitative meta-analyses indicated that there is limited available evidence that the total volume or patterns of sedentary behaviour are associated with health in children and adolescents when accounting for moderate-intensity to vigorous-intensity physical activity or focusing on studies with low risk of bias. Quality evidence from studies with robust designs and methods, objective measures of sitting, examining associations for various health outcomes, is needed to better understand if the overall volume or patterns of sedentary behaviour are independent determinants of health in children and adolescents.</td></tr>
<tr><td>Timeframe: Inception–November 2015</td></tr>
<tr><td>Total # of Studies: 88 (24 meta-analyses)</td></tr>
<tr><td>Exposure Definition: Total volume or patterns (i.e., breaks and bouts) of sedentary behavior (SB) measured objectively for observational studies and interventions specifically focused on decreasing SB for experimental studies.
Measures Steps: No
Measures Bouts: No
Examines HIIT: No</td></tr>
<tr><td>Outcomes Addressed: Adiposity: body-mass index, percentage of body fat. Cardiometabolic health: insulin and cholesterol. Health-related fitness. Respiratory health: asthma. Bone and musculoskeletal health: bone density. Examine Cardiorespiratory Fitness as Outcome: Yes</td></tr>
<tr><td>Populations Analyzed: Youth 2–18 years</td><td>Author-Stated Funding Source: This review was funded by the Australasian Child and Adolescent Obesity Research Network.</td></tr>
</table>

<table>
<tr><th colspan="2">Weight Status/Adiposity</th></tr>
<tr><td colspan="2">Systematic Review
Citation: LeBlanc AG, Spence JC, Carson V, et al. Systematic review of sedentary behaviour and health indicators in the early years (aged 0-4 years). Appl Physiol Nutr Metab. 2012;37(4):753-772. doi:10.1139/h2012-063.</td></tr>
<tr><td>Purpose: To present evidence examining the relationship between sedentary behavior and health indicators in the early years (0–4 years); specifically, to synthesize the best available evidence on the optimal dose (i.e., frequency, interruptions, time, and type) of sedentary behavior, as measured by direct and indirect methods, associated with improved health indicators in infants (1 month–1.0 year), toddlers (1.1–3.0 years), and preschoolers (3.1–4.99 years).</td><td rowspan="4">Abstract: Abstract: Accumulating evidence suggests that young children spend excessive time being sedentary. The purpose of this systematic review was to determine the relationship between sedentary behaviours and health indicators during the early years (ages 0–4 years). Using the Grading of Recommendations Assessment, Development, and Evaluation (GRADE) framework, this review aimed to present the best available evidence on the threshold of sedentary behaviour associated with healthy measures of adiposity, bone health, motor skill development, psychosocial health, cognitive development, and cardio-metabolic health indicators in infants, toddlers, and preschoolers. Online databases, personal libraries, and government documents were searched for relevant studies. Studies that included an intervention (or experimental) group or prospec-tive analysis were included. Twenty-one unique studies, representing 23 papers and 22 417 participants, met inclusion criteria; 7 studies included information on infants, 13 on toddlers, and 10 on preschoolers. Of these, 11, 6, and 8 stud-ies reported data on adiposity, psychosocial health, and cognitive development, respectively. No included study reported on motor skill development, bone, or cardiometabolic health indicators. In conclusion, this review found low- to moder-ate-quality evidence to suggest that increased television viewing is associated with unfavourable measures of adiposity and decreased scores on measures of psychosocial health and cognitive development. No evidence existed to indicate that television viewing is beneficial for improving psychosocial health or cognitive development. In several instances a dose–response relationship was evident between increased time spent watching television and decreased psychosocial health or cognitive development. This work may be used as evidence to inform public health guidelines. (PROSPERO registration: CRD4011001280.)</td></tr>
<tr><td>Timeframe: Inception–2011</td></tr>
<tr><td>Total # of Studies: 21</td></tr>
<tr><td>Exposure Definition: Sedentary behavior (SB) measured directly or self-reported; also measured as a composite of total time engaged in SB. Subgroup analysis by direct or indirect measure, by dose of SB.
Measures Steps: No
Measures Bouts: No
Examines HIIT: No</td></tr>
<tr><td>Outcomes Addressed: Adiposity: body mass index, body mass index z-scores, change in body fat, and mean sum of skinfolds.
Examine Cardiorespiratory Fitness as Outcome: No</td></tr>
<tr><td>Populations Analyzed: Children 0–4 years (1.1–3.0; 3.0–4.9)</td><td>Author-Stated Funding Source: Canadian Institute of Health Research.</td></tr>
</table>

<table>
<tr><th colspan="2">Weight Status/Adiposity</th></tr>
<tr><td colspan="2">Systematic Review
Citation: Pate RR, O'Neill JR, Liese AD, et al. Factors associated with development of excessive fatness in children and adolescents: a review of prospective studies. Obes Rev. 2013;14(8):645-658. doi:10.1111/obr.12035.</td></tr>
<tr><td>Purpose: To examine current scientific literature on the factors that predict the development of excessive fatness in children and adolescents.</td><td rowspan="4">Abstract: The purpose of this review was to examine the factors that predict the development of excessive fatness in children and adolescents. Medline, Web of Science and PubMed were searched to identify prospective cohort studies that evaluated the association between several variables (e.g. physical activity, sedentary behaviour, dietary intake and genetic, physiological, social cognitive, family and peer, school and community factors) and the development of excessive fatness in children and adolescents (5-18 years). Sixty-one studies met the eligibility criteria and were included. There is evidence to support the association between genetic factors and low physical activity with excessive fatness in children and adolescents. Current studies yielded mixed evidence for the contribution of sedentary behaviour, dietary intake, physiological biomarkers, family factors and the community physical activity environment. No conclusions could be drawn about social cognitive factors, peer factors, school nutrition and physical activity environments, and the community nutrition environment. There is a dearth of longitudinal evidence that examines specific factors contributing to the development of excessive fatness in childhood and adolescence. Given that childhood obesity is a worldwide public health concern, the field can benefit from large-scale, long-term prospective studies that use state-of-the-art measures in a diverse sample of children and adolescents.</td></tr>
<tr><td>Timeframe: 1990–June 2012</td></tr>
<tr><td>Total # of Studies: 4 (sedentary behavior)</td></tr>
<tr><td>Exposure Definition: Objectively measured sedentary time (accelerometer).
Measures Steps: No
Measures Bouts: No
Examines HIIT: No</td></tr>
<tr><td>Outcomes Addressed: Body-mass index, adiposity: dual x-ray absorptiometry, skin-fold thickness, bioelectrical impedance analysis.
Examine Cardiorespiratory Fitness as Outcome: No</td><td></td></tr>
<tr><td>Populations Analyzed: Youth 5–18</td><td>Author-Stated Funding Source: U.S. Department of Defense.</td></tr>
</table>

<table>
<tr><th colspan="2">Cardiometabolic Risk Factors, Weight Status/Adiposity</th></tr>
<tr><td colspan="2">Systematic Review
Citation: Tremblay MS, LeBlanc AG, Kho ME, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth. Int J Behav Nutr Phys Act. 2011;8:98. doi:10.1186/1479-5868-8-98.</td></tr>
<tr><td>Purpose: To gather, catalog, assess, and evaluate the available evidence examining sedentary behaviors in relation to selected health outcomes in children and youth 5–17 years of age and present a summary of the best available evidence.</td><td rowspan="5">Abstract: Accumulating evidence suggests that, independent of physical activity levels, sedentary behaviours are associated with increased risk of cardio-metabolic disease, all-cause mortality, and a variety of physiological and psychological problems. Therefore, the purpose of this systematic review is to determine the relationship between sedentary behaviour and health indicators in school-aged children and youth aged 5-17 years. Online databases (MEDLINE, EMBASE and PsycINFO), personal libraries and government documents were searched for relevant studies examining time spent engaging in sedentary behaviours and six specific health indicators (body composition, fitness, metabolic syndrome and cardiovascular disease, self-esteem, pro-social behaviour and academic achievement). 232 studies including 983,840 participants met inclusion criteria and were included in the review. Television (TV) watching was the most common measure of sedentary behaviour and body composition was the most common outcome measure. Qualitative analysis of all studies revealed a dose-response relation between increased sedentary behaviour and unfavourable health outcomes. Watching TV for more than 2 hours per day was associated with unfavourable body composition, decreased fitness, lowered scores for self-esteem and pro-social behaviour and decreased academic achievement. Meta-analysis was completed for randomized controlled studies that aimed to reduce sedentary time and reported change in body mass index (BMI) as their primary outcome. In this regard, a meta-analysis revealed an overall significant effect of -0.81 (95% CI of -1.44 to -0.17, p = 0.01) indicating an overall decrease in mean BMI associated with the interventions. There is a large body of evidence from all study designs which suggests that decreasing any type of sedentary time is associated with lower health risk in youth aged 5-17 years. In particular, the evidence suggests that daily TV viewing in excess of 2 hours is associated with reduced physical and psychosocial health, and that lowering sedentary time leads to reductions in BMI.</td></tr>
<tr><td>Timeframe: Inception–February 2010</td></tr>
<tr><td>Total # of Studies: 232</td></tr>
<tr><td>Exposure Definition: Objective and self-reported measures of sedentary behavior (SB). SB measures included measurements of sitting, low activity by accelerometer, TV watching, video gaming, non-school computer use and screen time.
Measures Steps: No
Measures Bouts: No
Examines HIIT: No</td></tr>
<tr><td>Outcomes Addressed: BMI. Other outcomes in the narrative: Body composition (waist circumference, skin folds) Fitness (cardiovascular fitness), metabolic syndrome and cardiovascular disease symptoms (clustering of disease risk factors).
Examine Cardiorespiratory Fitness as Outcome: Yes</td></tr>
<tr><td>Populations Analyzed: Youth, 2-19 years</td><td>Author-Stated Funding Source: Partial funding for the completion of this review came from the Public Health Agency of Canada.</td></tr>
</table>

<table>
<tr><th colspan="2">Weight Status/Adiposity</th></tr>
<tr><td colspan="2">Meta-Analysis
Citation: Wu L, Sun S, He Y, Jiang B. The effect of interventions targeting screen time reduction: a systematic review and meta-analysis. Medicine (Baltimore). 2016;95(27):e4029. doi:10.1097/MD.0000000000004029.</td></tr>
<tr><td>Purpose: To summarize the accumulated evidence of the impact of interventions targeting screen time reduction on body-mass index reduction and screen time reduction in a systematic review and meta-analysis of randomized controlled trials (RCTs) performed with adults and children.</td><td rowspan="5">Abstract: Previous studies have evaluated the effectiveness of interventions aimed at screen time reduction, but the results have been inconsistent. We therefore conducted a systematic review and meta-analysis of randomized controlled trials (RCTs) to summarize the accumulating evidence of the impact of interventions targeting screen time reduction on body mass index (BMI) reduction and screen time reduction. The PubMed, Embase, and Cochrane Central Register of Controlled Trials (CENTRAL) databases were searched for RCTs on the effect of interventions targeting screen time reduction. The primary and secondary outcomes were the mean difference between the treatment and control groups in the changes in BMI and changes in screen viewing time. A random effects model was used to calculate the pooled mean differences. Fourteen trials including 2238 participants were assessed. The pooled analysis suggested that interventions targeting screen time reduction had a significant effect on BMI reduction (-0.15 kg/m, P < 0.001, I = 0) and on screen time reduction (-4.63 h/w, P = 0.003, I = 94.6%). Subgroup analysis showed that a significant effect of screen time reduction was observed in studies in which the duration of intervention was <7 months and that the types of interventions in those studies were health promotion curricula or counseling. Interventions for screen time reduction might be effective in reducing screen time and preventing excess weight. Further rigorous investigations with larger samples and longer follow-up periods are still needed to evaluate the efficacy of screen time reduction both in children and in adults.</td></tr>
<tr><td>Timeframe: Inception–2015</td></tr>
<tr><td>Total # of Studies: 14</td></tr>
<tr><td>Exposure Definition: Interventions varied widely in attempts to reduce sedentary screen time, including classroom-based health promotion, automated TV viewing monitor and computer use reduction, counseling, and family-based health promotion.
Measures Steps: No
Measures Bouts: No
Examines HIIT: No</td></tr>
<tr><td>Outcomes Addressed: Changes in body-mass index.
Examine Cardiorespiratory Fitness as Outcome: No</td></tr>
<tr><td>Populations Analyzed: Youth <6, 6–17, >18</td><td>Author-Stated Funding Source: National Natural Science Foundation of China, Beijing Municipal Science and Technology Commission, and Military Medicine Innovation Fund.</td></tr>
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Table 3. Existing Systematic Reviews and Meta-Analyses Quality Assessment Chart

AMSTARExBP: SR/MA				
	Azevedo, 2016	Carson, 2016	Chinapaw, 2011	Cliff, 2016
Review questions and inclusion/exclusion criteria delineated prior to executing search strategy.	Yes	Yes	Yes	Yes
Population variables defined and considered in methods.	Yes	No	No	Yes
Was a comprehensive literature search performed?	Partially Yes	Yes	Partially Yes	Yes
Duplicate study selection and data extraction performed.	Yes	Yes	Yes	Yes
Search strategy clearly described.	Yes	Yes	Yes	Yes
Relevant grey literature included in review.	No	Yes	No	No
List of studies (included and excluded) provided.	No	No	No	No
Characteristics of included studies provided.	Yes	No	Yes	No
FITT defined and examined in relation to outcome effect sizes.	N/A	N/A	N/A	N/A
Scientific quality (risk of bias) of included studies assessed and documented.	Partially Yes	Partially Yes	Yes	Partially Yes
Results depended on study quality, either overall, or in interaction with moderators.	Yes	Yes	Yes	Yes
Scientific quality used appropriately in formulating conclusions.	Yes	Yes	Yes	Yes
Data appropriately synthesized and if applicable, heterogeneity assessed.	Yes	N/A	N/A	Yes
Effect size index chosen justified, statistically.	Yes	N/A	N/A	Partially Yes
Individual-level meta-analysis used.	No	N/A	N/A	No
Practical recommendations clearly addressed.	Yes	Yes	Yes	No
Likelihood of publication bias assessed.	Yes	No	No	Yes
Conflict of interest disclosed.	Yes	Yes	No	Yes

AMSTARExBP: SR/MA	LeBlanc, 2012	Pate, 2013	Tremblay, 2011	Wu, 2016
Review questions and inclusion/exclusion criteria delineated prior to executing search strategy.	Yes	Yes	Yes	Yes
Population variables defined and considered in methods.	Yes	Yes	No	Yes
Was a comprehensive literature search performed?	Yes	Yes	Yes	Yes
Duplicate study selection and data extraction performed.	Yes	Yes	Yes	Yes
Search strategy clearly described.	Yes	Yes	Yes	Yes
Relevant grey literature included in review.	No	No	No	No
List of studies (included and excluded) provided.	No	No	No	Yes
Characteristics of included studies provided.	Yes	No	Yes	Yes
FITT defined and examined in relation to outcome effect sizes.	N/A	N/A	N/A	N/A
Scientific quality (risk of bias) of included studies assessed and documented.	Partially Yes	No	Partially Yes	Yes
Results depended on study quality, either overall, or in interaction with moderators.	No	N/A	No	Yes
Scientific quality used appropriately in formulating conclusions.	Yes	N/A	Yes	Yes
Data appropriately synthesized and if applicable, heterogeneity assessed.	N/A	Yes	N/A	Yes
Effect size index chosen justified, statistically.	N/A	N/A	N/A	Yes
Individual-level meta-analysis used.	N/A	N/A	N/A	No
Practical recommendations clearly addressed.	Yes	Yes	Yes	Yes
Likelihood of publication bias assessed.	No	No	Yes	Yes
Conflict of interest disclosed.	Yes	Yes	Yes	Yes

Original Research

Table 4. Original Research Individual Evidence Summary Tables

<table>
<tr><td colspan="2">Original Research
Citation: Gabel L, Macdonald HM, Nettlefold L, McKay HA. Physical activity, sedentary time, and bone strength from childhood to early adulthood: a mixed longitudinal HR-pQCT study. J Bone Miner Res. 2017;32(7):1525-1536. doi:10.1002/jbmr.3115.</td></tr>
<tr><td colspan="2">Purpose: To prospectively evaluate the association between PA and growth-related adaptations in bone strength and its determinants at the distal tibia and radius in boys and girls.</td></tr>
<tr><td>Study Design: Prospective cohort study</td><td rowspan="5">Abstract: Bone strength is influenced by bone geometry, density, and bone microarchitecture, which adapt to increased mechanical loads during growth. Physical activity (PA) is essential for optimal bone strength accrual; however, less is known about how sedentary time influences bone strength and its determinants. Thus, our aim was to investigate the prospective associations between PA, sedentary time, and bone strength and its determinants during adolescence. We used HR-pQCT at distal tibia (8% site) and radius (7% site) in 173 girls and 136 boys (aged 9 to 20 years at baseline). We conducted a maximum of four annual measurements at the tibia (n = 785 observations) and radius (n = 582 observations). We assessed moderate-to-vigorous PA (MVPA) and sedentary time with accelerometers (ActiGraph GT1M). We aligned participants on maturity (years from age at peak height velocity) and fit a mixed-effects model adjusting for maturity, sex, ethnicity, leg muscle power, lean mass, limb length, dietary calcium, and MVPA in sedentary time models. MVPA was a positive independent predictor of bone strength (failure load [F.Load]) and bone volume fraction (BV/TV) at the tibia and radius, total area (Tt.Ar) and cortical porosity (Ct.Po) at the tibia, and negative predictor of load-to-strength ratio at the radius. Sedentary time was a negative independent predictor of Tt.Ar at both sites and Ct.Po at the tibia and a positive predictor of cortical thickness (Ct.Th), trabecular thickness (Tb.Th), and cortical bone mineral density (Ct.BMD) at the tibia. Bone parameters demonstrated maturity-specific associations with MVPA and sedentary time, whereby associations were strongest during early and mid-puberty. Our findings support the importance of PA for bone strength accrual and its determinants across adolescent growth and provide new evidence of a detrimental association of sedentary time with bone geometry but positive associations with microarchitecture. This study highlights maturity-specific relationships of bone strength and its determinants with loading and unloading. Future studies should evaluate the dose-response relationship and whether associations persist into adulthood. © 2017 American Society for Bone and Mineral Research.</td></tr>
<tr><td>Location: Not reported</td></tr>
<tr><td>Sample: 309
Attrition Rate: 21.3
Sample Power: Not reported</td></tr>
<tr><td>Intervention: No</td></tr>
<tr><td>Exposure Measurement Self-Reported:
Device-Measured: Accelerometers: a cutpoint of <100 counts per minute to classify sedentary time.
Measures Steps: No
Measures Bouts: No</td></tr>
<tr><td>Refers to Other Materials: Yes
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: Bone strength in tibia and radius: peripheral quantitative computed tomography. Total-body bone mineral free lean mass: dual energy x-ray absorptiometry.</td></tr>
<tr><td>Populations Analyzed: Youth 9–20</td><td>Author-Stated Funding Source: Canadian Institutes of Health Research.</td></tr>
</table>

<table>
<tr><td colspan="2">Original Research
Citation: Heidemann M, Mølgaard C, Husby S, et al. The intensity of physical activity influences bone mineral accrual in childhood: the childhood health, activity and motor performance school (the CHAMPS) study, Denmark. BMC Pediatr. 2013;13:32. doi:10.1186/1471-2431-13-32.</td></tr>
<tr><td colspan="2">Purpose: To assess the relationship between PA at different intensities, measured by accelerometers, and bone mineral content, bone mineral density, and bone area accrual measured by dual x-ray absorptiometry scans during a 2-year period.</td></tr>
<tr><td>Study Design: Prospective cohort study
Location: Denmark
Sample: 602
Attrition Rate: 18.86
Sample Power: Not reported
Intervention: No
Exposure Measurement
Device-Measured:
Accelerometer used to assess minutes per day in different intensity levels using Evenson cutpoints over 7 consecutive days.
Measures Steps: No
Measures Bouts: No</td><td>Abstract: BACKGROUND: Studies indicate genetic and lifestyle factors can contribute to optimal bone development. In particular, the intensity level of physical activity may have an impact on bone health. This study aims to assess the relationship between physical activity at different intensities and Bone Mineral Content (BMC), Bone Mineral Density (BMD) and Bone Area (BA) accretion. METHODS: This longitudinal study is a part of The CHAMPS study-DK. Whole-body DXA scans were performed at baseline and after two years follows up. BMC, BMD, and BA were measured. The total body less head (TBLH) values were used. Physical activity (PA) was recorded by accelerometers (ActiGraph, model GT3X). Percentages of different PA intensity levels were calculated and log odds of two intensity levels of activity relative to the third level were calculated. Multilevel regression analyses were used to assess the relationship between the categories of physical activity and bone traits. RESULTS: Of 800 invited children, 742 (93%) accepted to participate. Of these, 682/742 (92%) participated at follow up. Complete datasets were obtained in 602/742 (81%) children. Mean (range) of age was 11.5 years (9.7-13.9). PA at different intensity levels was for boys and girls respectively, sedentary 62% and 64%, low 29% for both genders and moderate to high 9% and 7% of the total time. Mean (range) BMC, BMD, and BA was 1179 g (563-2326), 0.84 g/cm2 (0.64-1.15) and 1393 cm2 (851-2164), respectively. Valid accelerometer data were obtained for a mean of 6.1 days, 13 hours per day. CONCLUSIONS: There 7was a positive relationship between the log odds of moderate to high-level PA versus low level activity and BMC, BMD and BA. Children with an increased proportion of time in moderate to high-level activity as opposed to sedentary and low-level activity achieved positive effects on BMC, BMD and BA.</td></tr>
<tr><td>Refers to Other Materials: Yes

Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: Bone mineral content, bone mineral density, and bone area using dual x-ray absorptiometry.</td></tr>
<tr><td>Populations Analyzed: Male; Female; Schoolchildren in 2nd–4th grade (age 7.2–12 years)</td><td>Author-Stated Funding Source: Nordea Foundation, TRYG Foundation, IMK Foundation, Region of Southern Denmark, Egmont Foundation, A. J. Andersen Foundation, Danish Rheumatism Association, and TEAM Denmark.</td></tr>
</table>

<table>
<tr><td colspan="2">Original Research
Citation: Ivuškāns A, Mäestu J, Jürimäe T. Sedentary time has a negative influence on bone mineral parameters in peripubertal boys: a 1-year prospective study. J Bone Miner Metab. 2015;33(1):85-92. doi:10.1007/s00774-013-0556-4.</td></tr>
<tr><td colspan="2">Purpose: To examine PA exposure to bone mass accrual during a longer observation period.</td></tr>
<tr><td>Study Design: Prospective cohort study</td><td rowspan="4">Abstract: One of the key determinants of adult skeletal health is the maximization of bone mass during the growth period. Physical activity (PA) in combination with lean mass and fat mass contribute to a great extent to bone mineral accrual; however, PA changes significantly during puberty. The aim of the present study was to examine PA exposure relative to bone mass acquisition during a longer observation period. Daily PA was measured with 7-day accelerometry and bone mineral parameters by DXA in 11- to 13-year-old peripubertal boys (n = 169). Similar testing was done after 1 calendar year. Changes in sedentary time were negatively related to changes in whole-body bone mineral density (BMD), lumbar spine bone mineral content (BMC), lumbar spine bone area (BA), femoral neck (FN) BMD, and FN BMC ($r > -0.157$; $p < 0.05$). Sedentary time emerged as the main PA level in predicting changes in FN BMC ($p = 0.027$) and in combination with vigorous PA predicting changes in FN BMD ($p < 0.024$). In addition to the effect of body composition on the skeleton, increase in sedentary time emerged as one main physical activity predictor (in addition to vigorous PA) of bone mineral acquisition during a 12-month period in peripubertal boys.</td></tr>
<tr><td>Location: Estonia</td></tr>
<tr><td>Sample: 169
Attrition Rate: 0
Sample Power: Not reported</td></tr>
<tr><td>Intervention: No</td></tr>
<tr><td>Exposure Measurement
Self-Reported:
Device-Measured: Accelerometer to measure total number of counts divided by the registered time (counts/minute, or cpm). Categories included: sedentary (<100 cpm), light (100 <1,999 cpm), moderate (2,000–3,999 cpm), and vigorous PA (>4,000 cpm).
Measures Steps: No
Measures Bouts: No</td></tr>
<tr><td>Refers to Other Materials: No
Examine Cardiorespiratory Fitness as Outcome: No</td><td>Outcomes Examined: Bone mineral density (g/cm^2), bone mineral content (grams), and bone area from whole body, lumbar spine, and femoral neck were assessed with dual-energy x-ray absorptiometry.</td></tr>
<tr><td>Populations Analyzed: Male, Ages 11–13</td><td>Author-Stated Funding Source: Estonian Ministry of Education and Science, European Social Fund’s Doctoral Studies, and Internationalisation Programme DoRa.</td></tr>
</table>

<table>
<tr><td colspan="2">Original Research
Citation: Vaitkeviciute D, Lätt E, Mäestu J, et al. Physical activity and bone mineral accrual in boys with different body mass parameters during puberty: a longitudinal study. PLoS One. 2014;9(10):e107759. doi:10.1371/journal.pone.0107759.</td></tr>
<tr><td colspan="2">Purpose: To investigate the longitudinal relationships between PA and bone mineral parameters in boys with different body mass status during pubertal growth spurts.</td></tr>
<tr><td>Study Design: Prospective cohort study
Location: Estonia
Sample: 206
Attrition Rate: 0
Sample Power: Not reported
Intervention: No
Exposure Measurement
Self-Reported:
Device-Measured: Accelerometer derived PA and sedentary time.
Measures Steps: No
Measures Bouts: No</td><td rowspan="2">Abstract: The aim of our longitudinal study was to investigate the relationships between physical activity and bone mass in boys with different body mass status during the years surrounding pubertal growth spurt. Two hundred and six boys entering puberty took part in this study. The subjects were divided into underweight (BMI < 15.35), normal weight (BMI ≥ 15.35-21.22), overweight (BMI ≥ 21.22-26.02) and obese (BMI > 26.02) groups at baseline according to age related categories. Whole-body DXA scans were performed at baseline, after 12 and 24 months to assess body composition (lean body mass, fat mass), and total body (TB), lumbar spine (LS) and femoral neck (FN) bone mineral density (BMD) parameters. Physical activity was measured by 7-day accelerometry. For longitudinal analysis, multilevel fixed effects regression models were constructed. Biological age, height and lean body mass had an effect for explanation of TB BMD, FN BMD and LS BMD. Moderate to vigorous physical activity (MVPA), vigorous physical activity (VPA) and sedentary time (SED) had the significant effect only on FN BMD. Being an underweight boy at the baseline indicated greater chance ($p<0.01$) to have lower TB BMD in the future (2 years at follow up) development, compared to normal weight (estimates = -0.038), overweight (estimates = -0.061) and obese boys (estimates = -0.106).</td></tr>
<tr><td>Refers to Other Materials: No
Examine Cardiorespiratory Fitness as Outcome: No</td></tr>
<tr><td>Populations Analyzed: Male, 12 years at baseline, Underweight (BMI: below 18.5), Normal/healthy weight (BMI: 18.5–24.9), Overweight (BMI: 25–29.9), Obese (BMI: 30 and above)</td><td>Outcomes Examined: Bone mineral density (g=cm^2) of total body, lumbar spine, and femoral neck measured using dual-energy x-ray absorptiometry.
Author-Stated Funding Source: Estonian Research Council.</td></tr>
</table>

Table 5. Original Research Bias Assessment Chart

Nutrition Evidence Library (NEL) Bias Assessment Tool (BAT): Original Research				
	Ivuskans, 2015	Gabel, 2017	Vaitkevicute, 2014	Heidemann, 2013
(???) = Can't Determine				
Inclusion/exclusion criteria similar across study groups.	Yes	Yes	Yes	Yes
Strategy for recruiting or allocating participants similar across study groups.	Yes	Yes	Yes	Yes
Allocation sequence randomly generated.	N/A	N/A	N/A	N/A
Group allocation concealed (i.e., assignments could not be predicted).	N/A	N/A	N/A	N/A
Distribution of critical confounding factors similar across study groups at baseline, or analysis controlled for differences between groups.	Yes	Yes	Yes	Yes
Accounted for variations in execution of study from proposed protocol or research plan.	N/A	N/A	N/A	N/A
Adherence to study protocols similar across study groups.	Yes	Yes	Yes	Yes
Investigators accounted for unintended concurrent exposures that were differentially experienced by study groups and might bias results.	Yes	Yes	No	Yes
Participants blinded to their intervention or exposure status.	N/A	N/A	N/A	N/A
Investigators blinded to participants' intervention or exposure status.	N/A	N/A	N/A	N/A
Outcome assessors blinded to participants' intervention or exposure status.	N/A	N/A	N/A	N/A
Valid and reliable measures used consistently across study groups to assess inclusion/exclusion criteria, exposures, outcomes, and confounders.	Yes	Yes	Yes	Yes
Length of follow-up similar across study groups.	Yes	Yes	Yes	Yes
In cases of high or differential loss to follow-up, impact assessed through sensitivity analysis or other adjustment.	N/A	No	N/A	No
Other sources of bias taken into account in design and/or analysis of study through matching or other statistical adjustment.	Yes	Yes	Yes	Yes
Adequate statistical methods used to assess primary outcomes.	Yes	Yes	Yes	Yes

Appendices

Appendix A: Analytical Framework

Topic Area
Youth

Systematic Review Question

In youth, what is the relationship between sedentary behavior and health outcomes?

a. What is the relationship between sedentary behavior and cardiometabolic risk factors?
b. Does sedentary behavior contribute to excessive weight gain that results in overweight or obesity?
c. What is the relationship between sedentary behavior and bone health?
d. Is there a dose-response relationship? If yes, what is the shape of the relationship?
e. Does the relationship vary by age, sex, race/ethnicity, socio-economic status, or weight status?

Population
Children, ages 0–18

Exposure
All types of sedentary behavior, including total sitting time, screen time, leisure-time sitting, and objective measures of sedentary time (e.g., accelerometers, heart rate monitors).

Comparison
Youth who participate in varying levels and types of sedentary behavior.

Endpoint Health Outcomes

- Bone density
- Bone strength
- Cardiorespiratory fitness
- Cardiometabolic risk factors
  - Blood pressure
  - Dyslipidemia
  - Glucose
  - Insulin resistance
  - Waist circumference
- Musculoskeletal health
- Obesity
- Overweight
- Weight gain

Appendix B: Final Search Strategy

Search Strategy: PubMed (Systematic Reviews, Meta-Analyses, Pooled Analyses, and High-Quality Reports)

Database: PubMed; Date of Search: 12/6/2016; 222 results

Set	Search Strategy
Limit: Language	(English[lang])
Limit: Exclude animal only	NOT ("Animals"[Mesh] NOT ("Animals"[Mesh] AND "Humans"[Mesh]))
Limit: Exclude adult only	NOT (("adult"[Mesh]) NOT (("adult"[Mesh]) AND ("infant"[Mesh] OR child[Mesh])))
Limit: Exclude subheadings	NOT (ad[sh] OR aa[sh] OR ci[sh] OR cn[sh] OR dh[sh] OR de[sh] OR dt[sh] OR em[sh] OR en[sh] OR es[sh] OR eh[sh] OR ge[sh] OR hi[sh] OR is[sh] OR ip[sh] OR lj[sh] OR ma[sh] OR mi[sh] OR og[sh] OR ps[sh] OR py[sh] OR pk[sh] OR pd[sh] OR po[sh] OR re[sh] OR rt[sh] OR rh[sh] OR st[sh] OR sd[sh] OR tu[sh] OR th[sh] OR tm[sh] OR tr[sh] OR us[sh] OR ut[sh] OR ve[sh] OR vi[sh])
Limit: Publication Date	AND ("2006/01/01"[PDAT] : "3000/12/31"[PDAT])
Limit: Publication Type Include	AND (systematic[sb] OR meta-analysis[pt] OR “systematic review”[tiab] OR “systematic literature review”[tiab] OR metaanalysis[tiab] OR "meta analysis"[tiab] OR metanalyses[tiab] OR "meta analyses"[tiab] OR "pooled analysis"[tiab] OR “pooled analyses”[tiab] OR "pooled data"[tiab])
Limit: Publication Type Exclude	NOT (“comment”[Publication Type] OR “editorial”[Publication Type])
Physical Activity	AND (("Active games"[tiab] OR "Active recreation"[tiab] OR "Exercise"[mh] OR "Exercise"[tiab] OR "High intensity activities"[tiab] OR "High intensity activity"[tiab] OR "Low intensity activities"[tiab] OR "Low intensity activity"[tiab] OR "Moderate to Vigorous Activities”[tiab] OR "Moderate to Vigorous Activity”[tiab] OR "Muscle-strengthening"[tiab] OR "Physical activity"[tiab] OR ("Recess"[tiab] AND ("Child"[tiab] OR "Youth"[tiab] OR Child[mh])) OR "Screen time"[tiab] OR "Sedentary lifestyle"[mh] OR "Television viewing"[tiab] OR "Television watching"[tiab] OR "Tummy time"[tiab] OR "TV viewing"[tiab] OR "TV watching"[tiab] OR "Video game"[tiab] OR "Video gaming"[tiab] OR "Vigorous Activities"[tiab] OR "Vigorous Activity"[tiab] OR "Play and Playthings"[mh]) OR (("Active play"[tiab] OR "Aerobic activities"[tiab] OR "Aerobic activity"[tiab] OR "Cardiovascular activities"[tiab] OR "Cardiovascular activity"[tiab] OR "Free Play"[tiab] OR "Outdoor Play"[tiab] OR "Physical activities"[tiab] OR "Recreational activities"[tiab] OR "Recreational activity"[tiab] OR

Set	Search Strategy
	"Sedentary"[tiab] OR "Walk"[tiab] OR "Walking"[tiab] OR "Youth sports"[tiab]) NOT medline[sb]))
Outcomes	AND (("Adiposity"[mh] OR "Asthma"[mh] OR "Blood glucose"[mh] OR "Blood lipids"[tiab] OR "Blood pressure"[mh] OR "Body composition"[mh] OR "Body Mass Index"[mh] OR "Bone density"[mh] OR "Cardiometabolic risk factors"[tiab] OR "Cardiometabolic risk factor"[tiab] OR "Dyslipidemias"[mh] OR "Fatness"[tiab] OR "Muscle mass"[tiab] OR "Musculoskeletal development"[mh] OR "Musculoskeletal fitness"[tiab] OR "Hyperglycemia"[mh] OR "Hypertension"[mh] OR "Insulin resistance"[mh] OR "Metabolic syndrome X"[mh] OR "Obesity"[mh] OR Diabetes Mellitus, Type 2[mh]) OR (("Adiposity"[tiab] OR "Asthma"[tiab] OR "Blood glucose"[tiab] OR "Blood pressure"[tiab] OR "Body composition"[tiab] OR "Body Mass Index"[tiab] OR BMI[tiab] OR "Dyslipidemia"[tiab] OR "Dyslipidemias"[tiab] OR "Musculoskeletal development"[tiab] OR "Hyperglycemia"[tiab] OR "Hypertension"[tiab] OR "Insulin resistance"[tiab] OR "Metabolic syndrome"[tiab] OR "Obese"[tiab] OR "Obesity"[tiab] OR "Type 2 Diabetes"[tiab] OR "Bone mineral content"[tiab] OR "Bone mineral density"[tiab] OR "Bone geometry"[tiab]) NOT medline[sb]))
Age	AND ((Child[mh] OR infant[mh]) OR (("Baby"[tiab] OR "Babies"[tiab] OR "Boy"[tiab] OR "Boys"[tiab] OR "Child"[tiab] OR "Children"[tiab] OR "Girl"[tiab] OR "Girls"[tiab] OR "Infant"[tiab] OR "Infants"[tiab] OR "Nursery school"[tiab] OR "Preschool"[tiab] OR "Pre school"[tiab] OR "Preschooler"[tiab] OR "Pre schooler"[tiab] OR "Pre-K"[tiab] OR "Toddler"[tiab] OR "Toddlers"[tiab]) NOT medline[sb]))

Search Strategy: CINAHL (Systematic Reviews, Meta-Analyses, Pooled Analyses, and High-Quality Reports)

Database: CINAHL; Date of Search: 12/8/16; 6 results
Terms searched in title or abstract

Set	Search Terms
Physical Activity	("Active games" OR "Active play" OR "Active recreation" OR "Aerobic activities" OR "Aerobic activity" OR "Cardiovascular activities" OR "Cardiovascular activity" OR "Exercise" OR "Exercise" OR "Free Play" OR "High intensity activities" OR "High intensity activity" OR "Low intensity activities" OR "Low intensity activity" OR "Moderate to Vigorous Activities" OR "Moderate to Vigorous Activity" OR "Muscle-strengthening" OR "Outdoor Play" OR "Physical activity" OR "Physical activities" OR ("Recess" AND ("Child" OR "Youth")) OR "Recreational activities" OR "Recreational activity" OR "Screen time" OR "Sedentary" OR "Sedentary lifestyle" OR "Television viewing" OR "Television watching" OR "Tummy time" OR "TV viewing" OR "TV watching" OR "Video game" OR "Video gaming" OR "Vigorous Activities" OR "Vigorous Activity" OR "Walk" OR "Walking" OR "Play and Playthings" OR "Youth sports")
Outcomes	AND ("Adiposity" OR "Adiposity" OR "Asthma" OR "Asthma" OR "Blood glucose" OR "Blood glucose" OR "Blood lipids" OR "Blood pressure" OR "Blood pressure" OR "Body composition" OR "Body composition" OR "Body Mass Index" OR "Body Mass Index" OR BMI OR "Bone density" OR "Cardiometabolic risk factors" OR "Cardiometabolic risk factor" OR "Dyslipidemia" OR "Dyslipidemias" OR "Dyslipidemias" OR "Fatness" OR "Muscle mass" OR "Musculoskeletal development" OR "Musculoskeletal development" OR "Musculoskeletal fitness" OR "Hyperglycemia" OR "Hyperglycemia" OR "Hypertension" OR "Hypertension" OR "Insulin resistance" OR "Insulin resistance" OR "Metabolic syndrome" OR "Metabolic syndrome X" OR "Obese" OR "Obesity" OR "Obesity" OR "Type 2 Diabetes" OR Diabetes Mellitus, Type 2 OR "Bone mineral content" OR "Bone mineral density" OR "Bone geometry")
Age	AND ("Baby" OR "Babies" OR "Boy" OR "Boys" OR "Child" OR "Children" OR "Girl" OR "Girls" OR "Infant" OR "Infants" OR "Nursery school" OR "Preschool" OR "Pre school" OR "Preschooler" OR "Pre schooler" OR "Pre-K" OR "Toddler" OR "Toddlers" OR "Child" OR "infant")
Systematic Reviews and Meta-Analyses	AND ("systematic review" OR "systematic literature review" OR metaanalysis OR "meta analysis" OR metanalyses OR "meta

Set	Search Terms
	analyses" OR "pooled analysis" OR “pooled analyses” OR "pooled data")
Limits	2006–present English language Peer reviewed Exclude Medline records Human

Search Strategy: Cochrane (Systematic Reviews, Meta-Analyses, Pooled Analyses, and High-Quality Reports)

Database: Cochrane; Date of Search: 12/15/16; 112 Results
Terms searched in title, abstract, or keywords

Set	Search Terms
Physical Activity	("Active games" OR "Active play" OR "Active recreation" OR "Aerobic activities" OR "Aerobic activity" OR "Cardiovascular activities" OR "Cardiovascular activity" OR "Exercise" OR "Exercise" OR "Free Play" OR "High intensity activities" OR "High intensity activity" OR "Low intensity activities" OR "Low intensity activity" OR "Moderate to Vigorous Activities” OR "Moderate to Vigorous Activity” OR "Muscle-strengthening" OR "Outdoor Play" OR "Physical activity" OR "Physical activities" OR ("Recess" AND ("Child" OR "Youth")) OR "Recreational activities" OR "Recreational activity" OR "Screen time" OR "Sedentary" OR "Sedentary lifestyle" OR "Television viewing" OR "Television watching" OR "Tummy time" OR "TV viewing" OR "TV watching" OR "Video game" OR "Video gaming" OR "Vigorous Activities" OR "Vigorous Activity" OR "Walk" OR "Walking" OR "Play and Playthings" OR "Youth sports")
Outcomes	AND ("Adiposity" OR "Adiposity" OR "Asthma" OR "Asthma" OR "Blood glucose" OR "Blood glucose" OR "Blood lipids" OR "Blood pressure" OR "Blood pressure" OR "Body composition" OR "Body composition" OR "Body Mass Index" OR "Body Mass Index" OR BMI OR "Bone density" OR "Cardiometabolic risk factors" OR "Cardiometabolic risk factor" OR "Dyslipidemia" OR "Dyslipidemias" OR "Dyslipidemias" OR "Fatness" OR "Muscle mass" OR "Musculoskeletal development" OR "Musculoskeletal development" OR "Musculoskeletal fitness" OR "Hyperglycemia" OR "Hyperglycemia" OR "Hypertension" OR "Hypertension" OR "Insulin resistance" OR "Insulin resistance" OR "Metabolic syndrome" OR "Metabolic syndrome X" OR "Obese" OR "Obesity" OR "Obesity" OR "Type 2 Diabetes" OR Diabetes Mellitus, Type 2 OR "Bone mineral content" OR "Bone mineral density" OR "Bone geometry")

Set	Search Terms
Age	AND ("Baby" OR "Babies" OR "Boy" OR "Boys" OR "Child" OR "Children" OR "Girl" OR "Girls" OR "Infant" OR "Infants" OR "Nursery school" OR "Preschool" OR "Pre school" OR "Preschooler" OR "Pre schooler" OR "Pre-K" OR "Toddler" OR "Toddlers" OR "Child" OR "infant")
Limits	2006–present Word variations not searched Cochrane Reviews and Other Reviews

Search Strategy: PubMed (Original Research)

Database: PubMed; Date of Search: 10/3/2017; 18 results

Set	Search Strategy
Limit: Language	(English[lang])
Limit: Exclude animal only	NOT ("Animals"[mh] NOT ("Animals"[mh] AND "Humans"[mh]))
Limit: Exclude adult only	NOT (("adult"[mh]) NOT (("adult"[mh]) AND ("infant"[mh] OR "child, preschool"[mh] OR "adolescent"[mh])))
Limit: Publication Date	AND ("2005/01/01"[PDAT] : "3000/12/31"[PDAT])
Limit: Publication Type Exclude	NOT ("comment"[Publication Type] OR "editorial"[Publication Type] OR "review"[Publication Type] OR systematic[sb] OR "meta-analysis"[publication type] OR "systematic review"[tiab] OR "systematic literature review"[tiab] OR metaanalysis[tiab] OR "meta analysis"[tiab] OR metanalyses[tiab] OR "meta analyses"[tiab] OR "pooled analysis"[tiab] OR "pooled analyses"[tiab] OR "pooled data"[tiab])
Study Design	AND ("Randomized controlled trial"[Publication Type] OR "Randomized controlled"[tiab] OR "Randomised controlled"[tiab] OR "Randomized trial"[tiab] OR "Randomised trial"[tiab] OR "Controlled trial"[tiab] OR "prospective studies"[mh] OR "longitudinal studies"[mh] OR "follow-up studies"[mh] OR ("Cohort"[tiab] AND "Prospective"[tiab]) OR ("Cohort"[tiab] AND "longitudinal"[tiab]) OR ("Cohort"[tiab] AND "Concurrent"[tiab]) OR ("follow*"[tiab] AND "Prospective*"[tiab]) OR ("follow*"[tiab] AND "over time"[tiab]))
Sedentary behavior	AND (("Screen time"[tiab] OR "Sedentary lifestyle"[mh] OR "Television viewing"[tiab] OR "Television watching"[tiab] OR "Sedentary lifestyle"[mh] OR "Computer time"[tiab] OR "Computer use"[tiab] OR "Screen time"[tiab] OR "Sitting"[tiab] OR "Television"[tiab] OR "TV viewing"[tiab] OR "TV watching"[tiab] OR "Video game"[tiab] OR "Video gaming"[tiab]) OR (("Sedentary"[tiab] OR "Inactivity"[tiab] OR "Physically inactive"[tiab] OR "Sedentarism"[tiab]) NOT medline[sb]))
Outcomes	AND (("Bone density"[mh] OR "Musculoskeletal development"[mh] OR "Musculoskeletal fitness"[tiab]) OR (("Musculoskeletal development"[tiab] OR "Bone mineral content"[tiab] OR "Bone-mineral

Set	Search Strategy
	content”[tiab] OR "Bone mineral density"[tiab] OR “Bone-mineral density”[tiab] OR "Bone geometry"[tiab] OR "Bone accrual"[tiab] OR "Bone structure"[tiab] OR "Bone strength"[tiab]) NOT medline[sb]))
Age	AND (("Adolescent"[mh] OR "Child, preschool"[mh] OR "Infant"[mh]) OR (("Adolescents"[tiab] OR "Baby"[tiab] OR "Babies"[tiab] OR "Child"[tiab] OR "Children"[tiab] OR "Infant"[tiab] OR "Infants"[tiab] OR "Nursery school"[tiab] OR "Pediatric"[tiab] OR "Preschool"[tiab] OR "Pre school"[tiab] OR "Preschooler"[tiab] OR "Pre schooler"[tiab] OR "Pre-K"[tiab] OR "Toddler"[tiab] OR "Toddlers"[tiab] OR "Teens"[tiab] OR "Teen"[tiab] OR "Teenager"[tiab] OR "Teenagers"[tiab] OR "Youth"[tiab] OR "Youths"[tiab] OR "Minors"[tiab] OR "Adolescent"[tiab] OR “girls”[tiab] OR “boys”[tiab]) NOT medline[sb]))

Search Strategy: CINAHL (Original Research)

Date of Search: 10/3/2017; 4 results

Terms searched in title or abstract

Set	Search Terms
Sedentary behavior	("Screen time" OR "Sedentary lifestyle" OR "Television viewing" OR "Television watching" OR "Computer time" OR "Computer use" OR "Screen time" OR "Sitting" OR "Television" OR "TV viewing" OR "TV watching" OR "Video game" OR "Video gaming" OR "Sedentary" OR "Inactivity" OR "Physically inactive" OR "Sedentarism" OR “media time” OR “media use”)
Outcomes	AND ("Bone density" OR "Musculoskeletal development" OR "Musculoskeletal fitness” OR "Musculoskeletal development" OR "Bone mineral content" OR "Bone mineral density" OR "Bone geometry" OR “bone health” OR “bone loss” OR “bone accrual” OR “bone structure” OR “bone strength”)
Age	AND ("Adolescent" OR "Infant" OR "Adolescents" OR "Baby" OR "Babies" OR "Child" OR "Children" OR "Infants" OR "Nursery school" OR "Pediatric" OR "Preschool" OR "Pre school" OR "Preschooler" OR "Pre schooler" OR "Pre-K" OR "Toddler" OR "Toddlers" OR “Teens” OR “Teen” OR “Teenager” OR “Teenagers” OR “Youth” OR “Youths” OR “minors”)
Original Research	NOT (“systematic review” OR “systematic literature review” OR "metaanalysis" OR "meta analysis" OR metanalyses OR "meta analyses" OR "pooled analysis" OR “pooled analyses” OR "pooled data")
Limits	English language Peer reviewed Exclude Medline records

Set	Search Terms
	Human 2005-present

Search Strategy: Cochrane (Original Research/Trials)

Database: Cochrane; Date of Search: 10/3/2017; 15 results

Terms searched in title, abstract, or keywords

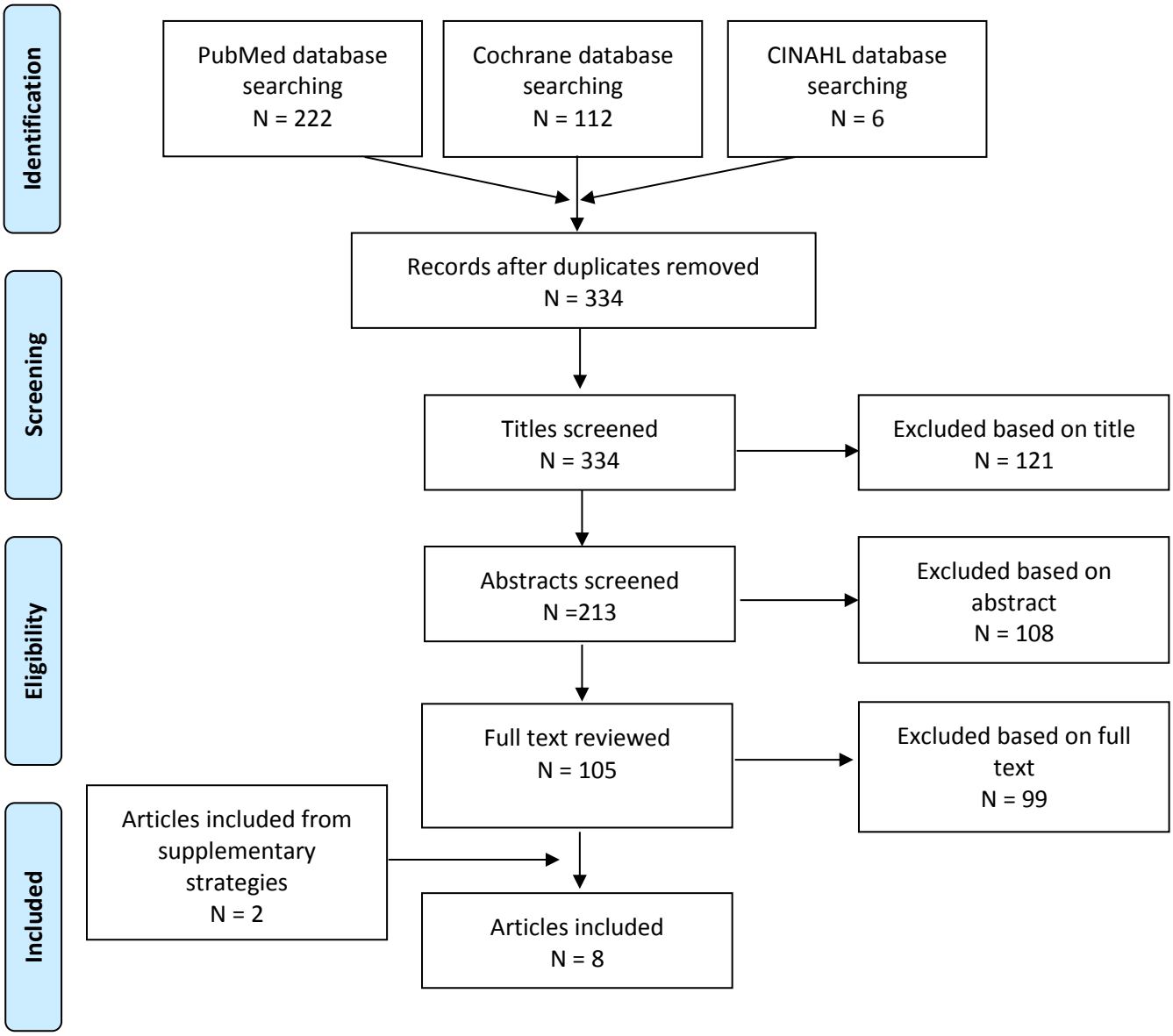
Set	Search Terms
Study Design	[mh “prospective studies”] OR
	[mh “longitudinal studies”] OR
	[mh “follow-up studies”] OR
	(“Randomized controlled” OR “Randomised controlled” OR “Randomized trial” OR “Randomised trial” OR “Controlled trial” OR (“Cohort” AND “Prospective”) OR (“Cohort” AND “longitudinal”) OR (“Cohort” AND “Concurrent”) OR (“follow” AND “Prospective”) OR (“follow” AND “over time”))
Sedentary behavior	AND ("Sedentary" OR "Sedentary lifestyle" OR "Inactivity" OR "Physically inactive" OR "Sedentarism" OR "Computer time" OR "Computer use" OR "Screen time" OR "Sitting" OR "Television" OR "TV viewing" OR "TV watching" OR "Video game" OR "Video gaming" OR “media use” OR “media time”)
Outcomes	AND ("Bone density" OR "Musculoskeletal development" OR "Musculoskeletal fitness” OR "Musculoskeletal development" OR "Bone mineral content" OR "Bone mineral density" OR "Bone geometry" OR “bone health” OR “bone loss” OR “bone accrual” OR “bone structure” OR “bone strength”)
Age	AND [mh infant] OR
	[mh “child, preschool”] OR
	[mh adolescent] OR
	("Adolescent" OR "Infant" OR "Adolescents" OR "Baby" OR "Babies" OR "Child" OR "Children" OR "Infants" OR "Nursery school" OR "Pediatric" OR "Preschool" OR "Pre school" OR "Preschooler" OR "Pre schooler" OR "Pre-K" OR "Toddler" OR "Toddlers" OR “Teens” OR “Teen” OR “Teenager” OR “Teenagers” OR “Youth” OR “Youths” OR “minors”)
Limits	2005-present Trials Word variations not searched

Supplementary Strategies:

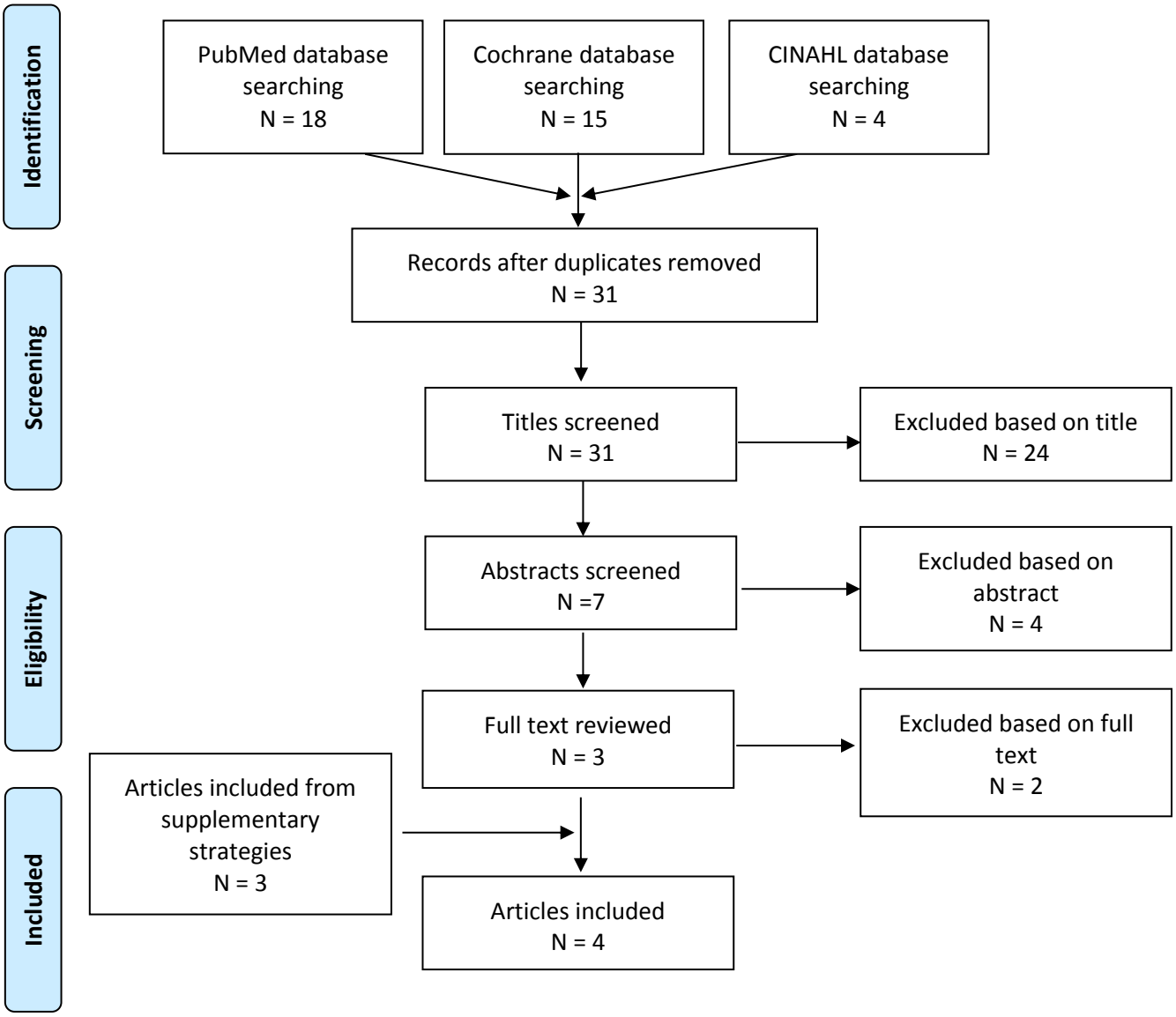
The Physical Activity Guidelines Youth Sub-committee also used a supplementary search strategy—expert consultation. Members suggested relevant articles that were not captured by the search strategies. Two relevant systematic reviews were identified: LeBlanc et al[7] and Pate et al[8]; and 3 original research studies were identified: Gabel et al[9]; Heidemann et al[10]; and Vaitkeviciute et al.[12]

Appendix C: Literature Tree

Existing Systematic Reviews, Meta-Analyses, Pooled Analyses, and Reports Literature Tree



Original Research Literature Tree



Appendix D: Inclusion/Exclusion Criteria

Youth Subcommittee
Q3. In youth, what is the relationship between sedentary behavior and health outcomes?

a. What is the relationship between sedentary behavior and cardiometabolic risk factors?
b. Does sedentary behavior contribute to excessive weight gain that results in overweight or obesity?
c. What is the relationship between sedentary behavior and bone health?
d. Is there a dose-response relationship? If yes, what is the shape of the relationship?
e. Does the relationship vary by age, sex, race/ethnicity, socio-economic status, or weight status?

Category	Inclusion/Exclusion Criteria	Notes/Rationale
Publication Language	**Include:** • Studies published with full text in English	
Publication Status	**Include:** • Studies published in peer-reviewed journals • Reports determined to have appropriate suitability and quality by PAGAC **Exclude:** • Grey literature, including unpublished data, manuscripts, abstracts, conference proceedings	
Research Type	**Include:** • Original research • Meta-analyses • Systematic reviews • Pooled analyses • Reports determined to have appropriate suitability and quality by PAGAC	
Study Subjects	**Include:** • Human subjects	
Age of Study Subjects	**Include:** • Children ages 0–18 **Exclude:** • Adults	
Health Status of Study Subjects	**Include:** • Healthy children • Overweight or obese children **Exclude:** • Children with disabilities • Children with chronic conditions • Nonambulatory youth • Hospitalized patients	

Date of Publication	**Include:** • Systematic review, meta-analysis, pooled analysis, and reports published 2006–present • Original research published 2005–present	
Study Design	**Include:** • Randomized trials • Non-randomized trials • Prospective cohort studies • Retrospective cohort studies • Case-control studies • Before-after studies • Time series • Systematic reviews • Meta-analyses • Pooled analyses • Reports **Exclude:** • Narrative reviews • Commentaries • Editorials • Cross-sectional studies • Study protocol	
Intervention/ Exposure	**Include studies in which the exposure or intervention is:** • All types of sedentary behavior **Exclude:** • Studies that do not include sedentary behavior as the primary exposure variable or used solely as a confounding variable	

Outcome	**Systematic Review, Meta-Analysis, Pooled Analysis, and Report Criteria:**
	Include studies in which the outcome is:
	• Bone density
	• Bone strength
	• Cardiorespiratory fitness
	• Cardiometabolic risk factors
	  ○ Blood pressure
	  ○ Dyslipidemia
	  ○ Glucose
	  ○ Insulin resistance
	  ○ Waist circumference
	• Musculoskeletal health
	• Obesity
	• Overweight	

	• Weight gain **Original Research Criteria:** **Include studies in which the outcome is:** • Bone density • Musculoskeletal development • Musculoskeletal fitness • Musculoskeletal development • Bone mineral content • Bone mineral density • Bone geometry • Bone health • Bone loss • Bone accrual • Bone structure • Bone strength	

Appendix E: Rationale for Exclusion at Abstract or Full-Text Triage for Existing Systematic Reviews, Meta-Analyses, Pooled Analyses, and Reports

The table below lists the excluded articles with at least one reason for exclusion, but may not reflect all possible reasons.

Citation	Outcome	Population	Study Design	Exposure	Not ideal fit for replacement of de novo search	Other
Adachi-Mejia AM, Longacre MR, Gibson JJ, Beach ML, Titus-Ernstoff LT, Dalton MA. Children with a TV in their bedroom at higher risk for being overweight. *Int J Obes (Lond).* 2007;31(4):644-651.				X		
Adatia I, Haworth SG, Wegner M, et al. Clinical trials in neonates and children: report of the pulmonary hypertension academic research consortium pediatric advisory committee. *Pulm Circ.* 2013;3(1):252-266. doi:10.4103/2045-8932.109931.				X		
Aftosmes-Tobio A, Ganter C, Gicevic S, et al. A systematic review of media parenting in the context of childhood obesity research. *BMC Public Health.* 2016;16:320. doi:10.1186/s12889-016-2981-5.				X		
Aguilar Cordero MJ, Ortegón Piñero A, Mur Vilar N, et al. Physical activity programmes to reduce overweight and obesity in children and adolescents; a systematic review. *Nutr Hosp.* 2014;30(4):727-740. doi:10.3305/nh.2014.30.4.7680.						X
Alberdi G, McNamara AE, Lindsay KL, et al. The association between childcare and risk of childhood overweight and obesity in children aged 5 years and under: a systematic review. *Eur J Pediatr.* 2016;175(10):1277-1294. doi:10.1007/s00431-016-2768-9.				X		
Alexander D, Rigby MJ, Di Mattia P, Zscheppang A. Challenges in finding and measuring behavioural determinants of childhood obesity in Europe. *Z Gesundh Wiss.* 2015;23(2):87-94.	X					
Antwi F, Fazylova N, Garcon MC, Lopez L, Rubiano R, Slyer JT. The effectiveness of web-based programs on the reduction of childhood obesity in school-aged children: a systematic review. *JBI Libr Syst Rev.* 2012;10(suppl 42):1-14.			X			
Arteburn DE. Obesity in children. *BMJ Clin Evid*. 2007:110-111. pii:0325.				X		
Atkin AJ, Ekelund U, Moller NC, et al. Sedentary time in children: influence of accelerometer processing on health relations. *Med Sci Sports Exerc.* 2013;45(6):1097-1104. doi:10.1249/MSS.0b013e318282190e.	X					
Atlantis E, Barnes EH, Singh MA. Efficacy of exercise for treating overweight in children and adolescents: a systematic review. *Int J Obes (Lond).* 2006;30(7):1027-1040.				X		
Azevedo LB, Ling J, Soos I, Robalino S, Ells L. Effectiveness of sedentary behaviour interventions on body mass index in children: systematic review			X			

Citation	Outcome	Population	Study Design	Exposure	Not ideal fit for replacement of de novo search	Other
and meta-analysis. *Med Sci Sports Exerc.* 2016;48(5 suppl 1):375.						
Bäcklund C, Sundelin G, Larsson C. Effect of a 1-year lifestyle intervention on physical activity in overweight and obese children. *Adv Physiother.* 2011;13(3):87-96. doi:10.3109/14038196.2011.566353.			X			
Bäcklund C, Sundelin G, Larsson C. Effects of a 2-year lifestyle intervention on physical activity in overweight and obese children. *Adv Physiother.* 2011;13(3):97-109. doi:10.3109/14038196.2011.562540.			X			
Barr-Anderson DJ, Adams-Wynn AW, DiSantis KI, Kumanyika S. Family-focused physical activity, diet and obesity interventions in African-American girls: a systematic review. *Obes Rev.* 2013;14(1):29-51. doi:10.1111/j.1467-789X.2012.01043.x.				X		
Beets MW, Beighle A, Erwin HE, Huberty JL. After-school program impact on physical activity and fitness: a meta-analysis. *Am J Prev Med.* 2009;36(6):527-537. doi:10.1016/j.amepre.2009.01.033.				X		
Berge JM. A review of familial correlates of child and adolescent obesity: what has the 21st century taught us so far? *Int J Adolesc Med Health.* 2009;21(4):457-483.	X					
Berge JM, Everts JC. Family-based interventions targeting childhood obesity: a meta-analysis. *Child Obes.* 2011;7(2):110-121. doi:10.1089/chi.2011.07.02.1004.berge.				X		
Birch L, Perry R, Penfold C, Beynon R, Hamilton-Shield J. What change in body mass index is needed to improve metabolic health status in childhood obesity: protocol for a systematic review. *Syst Rev.* 2016;5(1):120. doi:10.1186/s13643-016-0299-0.			X			
Bleich SN, Ku R, Wang YC. Relative contribution of energy intake and energy expenditure to childhood obesity: a review of the literature and directions for future research. *Int J Obes (Lond).* 2011;35(1):1-15. doi:10.1038/ijo.2010.252.				X		
Blohm D, Ploch T, Apelt S. Efficacy of exercise therapy to reduce cardiometabolic risk factors in overweight and obese children and adolescents: a systematic review. *Dtsch Med Wochenschr.* 2012;137(50):2631-2636. doi:10.1055/s-0032-1327333.					X	
Bochner RE, Sorensen KM, Belamarich PF. The impact of active video gaming on weight in youth: a meta-analysis. *Clin Pediatr (Phila).* 2015;54(7):620-628. doi:10.1177/0009922814545165.				X		
Brown EC, Buchan DS, Baker JS, Wyatt FB, Bocalini DS, Kilgore L. A systematised review of primary				X		

Citation	Outcome	Population	Study Design	Exposure	Not ideal fit for replacement of de novo search	Other
school whole class child obesity interventions: effectiveness, characteristics, and strategies. *Biomed Res Int.* 2016;2016:4902714. doi:10.1155/2016/4902714.						
Brown T, Summerbell C. Systematic review of school-based interventions that focus on changing dietary intake and physical activity levels to prevent childhood obesity: an update to the obesity guidance produced by the National Institute for Health and Clinical Excellence. *Obes Rev.* 2009;10(1):110-141. doi:10.1111/j.1467-789X.2008.00515.x.				X		
Bryant MJ, Lucove JC, Evenson KR, Marshall S. Measurement of television viewing in children and adolescents: a systematic review. *Obes Rev.* 2007;8(3):197-209.			X	X		
Bustamante EE, Williams CF, Davis CL. Physical activity interventions for neurocognitive and academic performance in overweight and obese youth: a systematic review. *Pediatr Clin North Am.* 2016;63(3):459-480. doi:10.1016/j.pcl.2016.02.004.	X					
Caleyachetty R, Echouffo-Tcheugui JB, Tait CA, Schilsky S, Forrester T, Kengne AP. Prevalence of behavioural risk factors for cardiovascular disease in adolescents in low-income and middle-income countries: an individual participant data meta-analysis. *Lancet Diabetes Endocrinol.* 2015;3(7):535-544. doi:10.1016/S2213-8587(15)00076-5.				X		
Canoy D, Bundred P. Obesity in children. *BMJ Clin Evid.* 2011;2011:pii:0325.				X		
Carlin A, Murphy MH, Gallagher AM. Do interventions to increase walking work? A systematic review of interventions in children and adolescents. *Sports Med.* 2016;46(4):515-530. doi:10.1007/s40279-015-0432-6.	X					
Cattuzzo MT, Dos Santos Henrique R, Ré AH, et al. Motor competence and health related physical fitness in youth: a systematic review. *J Sci Med Sport.* 2016;19(2):123-129. doi:10.1016/j.jsams.2014.12.004.				X		
Chai LK, Burrows T, May C, Brain K, Wong See D, Collins C. Effectiveness of family-based weight management interventions in childhood obesity: an umbrella review protocol. *JBI Database System Rev Implement Rep.* 2016;14(9):32-39.			X			
Chaplais E, Naughton G, Thivel D, Courteix D, Greene D. Smartphone interventions for weight treatment and behavioral change in pediatric obesity: a systematic review. *Telemed J E Health.* 2015;21(10):822-830. doi:10.1089/tmj.2014.0197.			X			X
Chen SR, Chiu HW, Lee YJ, Sheen TC, Jeng C. Impact of pubertal development and physical activity on heart rate variability in overweight and			X			

Citation	Outcome	Population	Study Design	Exposure	Not ideal fit for replacement of de novo search	Other
obese children in Taiwan. *J Sch Nurs.* 2012;28(4):284-290. doi:10.1177/1059840511435248.						
Chen YC, Tu YK, Huang KC, Chen PC, Chu DC, Lee YL. Pathway from central obesity to childhood asthma. Physical fitness and sedentary time are leading factors. *Am J Respir Crit Care Med.* 2014;189(10):1194-1203. doi:10.1164/rccm.201401-0097OC.			X			
Ciampa PJ, Kumar D, Barkin SL, et al. Interventions aimed at decreasing obesity in children younger than 2 years: a systematic review. *Arch Pediatr Adolesc Med.* 2010;164(12):1098-1104. doi:10.1001/archpediatrics.2010.232.				X		
Clark JE. Does the type of intervention method really matter for combating childhood obesity? A systematic review and meta-analysis. *J Sports Med Phys Fitness*. 2014;55(12):1524-1543.				X		
Colquitt JL, Loveman E, O'Malley C, et al. Diet, physical activity, and behavioural interventions for the treatment of overweight or obesity in preschool children up to the age of 6 years. 2016;(3):CD012105. doi:10.1002/14651858.CD012105.				X		
Cote AT, Devlin AM, Panagiotopoulos C. Initial screening of children treated with second-generation antipsychotics points to an association between physical activity and insulin resistance. *Pediatr Exerc Sci*. 2014;26(4):455-462. doi:10.1123/pes.2014-0076.				X		
Cradock AL, Barrett JL, Kenney EL, et al. Using cost-effectiveness analysis to prioritize policy and programmatic approaches to physical activity promotion and obesity prevention in childhood. *Prev Med.* 2017;95(suppl):S17-S27. doi:10.1016/j.ypmed.2016.10.017.	X					
Craigie AM, Lake AA, Kelly SA, Adamson AJ, Mathers JC. Tracking of obesity-related behaviours from childhood to adulthood: a systematic review. *Maturitas*. 2011;70(3):266-284. doi:10.1016/j.maturitas.2011.08.005.	X					
De Bourdeaudhuij I, Van Cauwenberghe E, Spittaels H, et al. School-based interventions promoting both physical activity and healthy eating in Europe: a systematic review within the HOPE project. *Obes Rev.* 2011;12(3):205-216. doi:10.1111/j.1467-789X.2009.00711.x.					X	
Dellert JC, Johnson P. Interventions with children and parents to improve physical activity and body mass index: a meta-analysis. *Am J Health Promot*. 2014;28(4):259-267. doi:10.4278/ajhp.120628-LIT-313.				X		
DeMattia L, Lemont L, Meurer L. Do interventions to limit sedentary behaviours change behaviour						

Citation	Outcome	Population	Study Design	Exposure	Not ideal fit for replacement of de novo search	Other
and reduce childhood obesity? A critical review of the literature. *Obes Rev.* 2007;8(1):69-81.						
Demetriou Y, Höner O. Physical activity interventions in the school setting: a systematic review. *Psychology of Sport and Exercise.* 2012;13(2):186-196. doi:10.1016/j.psychsport.2011.11.006.						
Dennison ME, Sisson SB, Lora K, Stephens LD, Copeland KC, Caudillo C. Assessment of body mass index, sugar sweetened beverage intake and time spent in physical activity of American Indian children in Oklahoma. *J Community Health.* 2015;40(4):808-814. doi:10.1007/s10900-015-0004-6.			X			
Dobbins M, Husson H, DeCorby K, LaRocca RL. School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6 to 18. *Cochrane Database Syst Rev.* 2013;(2):CD007651. doi:10.1002/14651858.CD007651.pub2.				X		
Duch H, Fisher EM, Ensari I, Harrington A. Screen time use in children under 3 years old: a systematic review of correlates. *Int J Behav Nutr Phys Act.* 2013;10:102. doi:10.1186/1479-5868-10-102.				X		
Dunton GF, Kaplan J, Wolch J, Jerrett M, Reynolds KD. Physical environmental correlates of childhood obesity: a systematic review. *Obes Rev.* 2009;10(4):393-402. doi:10.1111/j.1467-789X.2009.00572.x.	X					
Ekelund U, Luan J, Sherar LB, Esliger DW, Griew P, Cooper A; International Children's Accelerometry Database (ICAD) Collaborators. Moderate to vigorous physical activity and sedentary time and cardiometabolic risk factors in children and adolescents. *JAMA.* 2012;307(7):704-712. doi:10.1001/jama.2012.156.				X		
Escalante Y, Saavedra JM, García-Hermoso A, Domínguez AM. Improvement of the lipid profile with exercise in obese children: a systematic review. *Prev Med.* 2012;54(5):293-301. doi:10.1016/j.ypmed.2012.02.006.				X		
Fedewa MV, Gist NH, Evans EM, Dishman RK. Exercise and insulin resistance in youth: a meta-analysis. *Pediatrics.* 2014;133(1):e163-e174. doi:10.1542/peds.2013-2718.				X		
Ferreira I, van der Horst K, Wendel-Vos W, Kremers S, van Lenthe FJ, Brug J. Environmental correlates of physical activity in youth—a review and update. *Obes Rev.* 2007;8(2):129-154.	X	X		X		
Fisberg M, Maximino P, Kain J, Kovalskys I. Obesogenic environment—intervention opportunities. *J Pediatr (Rio J).* 2016;92(3 suppl 1):S30-S39. doi:10.1016/j.jped.2016.02.007.	X	X		X		

Citation	Outcome	Population	Study Design	Exposure	Not ideal fit for replacement of de novo search	Other
Fleischhacker S, Roberts E, Camplain R, Evenson KR, Gittelsohn J. Promoting physical activity among Native American youth: a systematic review of the methodology and current evidence of physical activity interventions and community-wide initiatives. *J Racial Ethn Health Disparities.* 2016;3(4):608-624.						X
Flodmark CE, Marcus C, Britton M. Interventions to prevent obesity in children and adolescents: a systematic literature review. *Int J Obes (Lond).* 2006;30(4):579-589.				X		
Foulds HJ, Rodgers CD, Duncan V, Ferguson LJ. A systematic review and meta-analysis of screen time behaviour among North American indigenous populations. *Obes Rev.* 2016;17(5):455-466. doi:10.1111/obr.12389.	X			X		
Frerichs L, Ataga O, Corbie-Smith G, Tessler Lindau S. Child and youth participatory interventions for addressing lifestyle-related childhood obesity: a systematic review. *Obes Rev*. 2016;17(12):1276-1286. doi:10.1111/obr.12468.				X		
Galantino ML, Galbavy R, Quinn L. Therapeutic effects of yoga for children: a systematic review of the literature. *Pediatr Phys Ther.* 2008;20(1):66-80. doi:10.1097/PEP.0b013e31815f1208.						X
Gao Z, Chen S. Are field-based exergames useful in preventing childhood obesity? A systematic review. *Obes Rev*. 2014;15(8):676-691. doi:10.1111/obr.12164.				X		
García-Hermoso A, Carmona-López MI, Saavedra JM, Escalante Y. Physical exercise, detraining and lipid profile in obese children: a systematic review. *Arch Argent Pediatr.* 2014;112(6):519-525. doi:10.1590/S0325-00752014000600007.				X	X	
García-Hermoso A, Sánchez-López M, Escalante Y, Saavedra JM, Martínez-Vizcaíno V. Exercise-based interventions and C-reactive protein in overweight and obese youths: a meta-analysis of randomized controlled trials. *Pediatr Res.* 2016;79(4):522-527. doi:10.1038/pr.2015.274.		X				
García-Hermoso A, Saavedra JM, Escalante Y. Effects of exercise on resting blood pressure in obese children: a meta-analysis of randomized controlled trials. *Obes Rev.* 2013;14(11):919-928. doi:10.1186/s13098-015-0034-3.				X		
Golley RK, Hendrie GA, Slater A, Corsini N. Interventions that involve parents to improve children's weight-related nutrition intake and activity patterns—what nutrition and activity targets and behaviour change techniques are associated with intervention effectiveness? 2011;12(2):114-130. doi:10.1111/j.1467-789X.2010.00745.x.	X	X		X		
Gomes TN, Katzmarzyk PT, dos Santos FK, Souza M, Pereira S, Maia JA. Overweight and obesity in			X			

Citation	Outcome	Population	Study Design	Exposure	Not ideal fit for replacement of de novo search	Other
Portuguese children: prevalence and correlates. *Int J Environ Res Public Health.* 2014;11(11):11398-11417. doi:10.3390/ijerph111111398.						
Gorga E, Regazzoni V, Bansilal S, et al. School and family-based interventions for promoting a healthy lifestyle among children and adolescents in Italy: a systematic review. *J Cardiovasc Med (Hagerstown).* 2016;17(8):547-555. doi:10.2459/JCM.0000000000000404.	X					
Gray C, Gibbons R, Larouche R, et al. What is the relationship between outdoor time and physical activity, sedentary behaviour, and physical fitness in children? A systematic review. *Int J Environ Res Public Health.* 2015;12(6):6455-6474. doi:10.3390/ijerph120606455.	X					
Guerra PH, Nobre MR, da Silveira JA, Taddei JA. School-based physical activity and nutritional education interventions on body mass index: a meta-analysis of randomised community trials—project PANE. *Prev Med.* 2014;61:81-89. doi:10.1016/j.ypmed.2014.01.005.				X		
Guinhouya BC, Samouda H, Zitouni D, Vilhelm C, Hubert H. Evidence of the influence of physical activity on the metabolic syndrome and/or on insulin resistance in pediatric populations: a systematic review. *Int J Pediatr Obes.* 2011;6(5-6):361-388. doi:10.3109/17477166.2011.605896.				X		
Guy S, Ratzi-Leewing A, Gwadry-Sridhar F. Moving beyond the stigma: systematic review of video games and their potential to combat obesity. *Int J Hypertens*. 2011;2011:179124. doi:10.4061/2011/179124.	X					
Habibzadeh N, Farhad R, Hasan D. The effect of walking exercise on the amount of fat mass and serum insulin in obese girls. *Journal of Zanjan University of Medical Sciences & Health Services*. 2011;18(73):18-25.		X				
Haines MS, Kim DH. A study of the effects of physical activity on asthmatic symptoms and obesity risk in elementary school-aged children. *Am J Health Educ*. 2013;44(3):156-161. doi:10.1080/19325037.2013.779905.		X				
Hajinia M, Hamedinia MR, Haghighi AH, Davarzani Z. The relationship between cardiovascular fitness and physical activity with obesity and changes in their pattern among 12-16 year-old boys. *Iranian Journal of Endocrinology & Metabolism*. 2013;15(2):1-10.			X			
Hammad SS, Berry DC. The child obesity epidemic in Saudi Arabia: a review of the literature. *J Transcult Nurs.* September 2016.	X	X				
Hammersley ML, Jones RA, Okely AD. Parent-focused childhood and adolescent overweight and obesity ehealth interventions: a systematic review				X		

Citation	Outcome	Population	Study Design	Exposure	Not ideal fit for replacement of de novo search	Other
and meta-analysis. *J Med Internet Res*. 2016;18(7):e203. doi:10.2196/jmir.5893.						
Haney EM, Huffman LH, Bougatsos C, et al. Screening for lipid disorders in children and adolescents [Internet]. *U.S. Preventive Services Task Force Evidence Syntheses, formerly Systematic Evidence Reviews*. Report No.: 07-0598-EF-1. Rockville, MD: Agency for Healthcare Research and Quality; 2007.	X			X		
Hansen D, Marinus N, Remans M, et al. Exercise tolerance in obese vs. lean adolescents: a systematic review and meta-analysis. *Obes Rev.* 2014;15(11):894-904. doi:10.1111/obr.12202.	X					
Harris KC, Kuramoto LK, Schulzer M, Retallack JE. Effect of school-based physical activity interventions on body mass index in children: a meta-analysis. *CMAJ*. 2009;180(7):719-726. doi:10.1503/cmaj.080966.				X		
Hendrie GA, Brindal E, Corsini N, Gardner C, Baird D, Golley RK. Combined home and school obesity prevention interventions for children: what behavior change strategies and intervention characteristics are associated with effectiveness? *Health Educ Behav.* 2012;39(2):159-171. doi:10.1177/1090198111420286.	X					
Hildebrand M, Oglund GP, Wells JC, Ekelund U. Prenatal, birth and early life predictors of sedentary behavior in young people: a systematic review. *Int J Behav Nutr Phys Act.* 2016;13:63. doi:10.1186/s12966-016-0389-3.	X			X		
Hind K, Burrows M. Weight-bearing exercise and bone mineral accrual in children and adolescents: a review of controlled trials. *Bone*. 2007;40:14-27. doi:10.1016/j.bone.2006.07.006.				X		
Hinkley T, Salmon J, Okely AD, Trost SG. Correlates of sedentary behaviours in preschool children: a review. *Int J Behav Nutr Phys Act*. 2010;7:66. doi:10.1186/1479-5868-7-66.	X			X		
Ho M, Garnett SP, Baur L, et al. Effectiveness of lifestyle interventions in child obesity: systematic review with meta-analysis. *Pediatrics.* 2012;130(6):e1647-e1671. doi:10.1542/peds.2012-1176.				X		
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Citation	Outcome	Population	Study Design	Exposure	Not ideal fit for replacement of de novo search	Other
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Citation	Outcome	Population	Study Design	Exposure	Not ideal fit for replacement of de novo search	Other
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Mistry SK, Puthussery S. Risk factors of overweight and obesity in childhood and adolescence in South Asian countries: a systematic review of the		X		X		

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Schwartz C, King NA, Perreira B, Blundell JE, Thivel D. A systematic review and meta-analysis of energy and macronutrient intake responses to physical activity interventions in children and	X					

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Thompson S, Ekelund U, Jebb S, et al. A proposed method of bias adjustment for meta-analyses of published observational studies. *Int J Epidemiol*. 2011;40(3):765-777. doi:10.1093/ije/dyq248.					X	
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Citation	Outcome	Population	Study Design	Exposure	Not ideal fit for replacement of de novo search	Other
review of the effects on physical fitness components and cardiovascular risk factors. *Sports Med.* 2014;44(8):1139-1152. doi:10.1007/s40279-014-0193-7.						
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Vissers D, Hens W, Hansen D, Taeymans J. The effect of diet or exercise on visceral adipose tissue in overweight youth. *Med Sci Sports Exerc.* 2016;48(7):1415-1424. doi:10.1249/MSS.0000000000000888.				X		
Voskuil VR, Frambes DA, Robbins LB. Effect of physical activity interventions for girls on objectively measured outcomes: a systematic review of randomized controlled trials. *J Pediatr Health Care.* 2017;31(1):75-87.doi:10.1016/j.pedhc.2016.03.003.				X		
Wahi G, Parkin PC, Beyene J, Uleryk EM, Birken CS. Effectiveness of interventions aimed at reducing screen time in children: a systematic review and meta-analysis of randomized controlled trials. *Arch Pediatr Adolesc Med.* 2011;165(11):979-986. doi:10.1001/archpediatrics.2011.122.				X		
Walker SE, Smolkin ME, O'Leary ML, et al. Predictors of retention and BMI loss or stabilization in obese youth enrolled in a weight loss intervention. *Obes Res Clin Pract*. 2012;6(4):e330-e339.	X		X			
Wang Y, Wu Y, Wilson RF, et al. Childhood obesity prevention programs: comparative effectiveness review and meta-analysis. *AHRQ Comparative Effectiveness Review No. 115*. AHRQ Publication No. 13-EHC081-EF. Rockville, MD: Agency for Healthcare Research and Quality; 2013.				X		
Ward DS, Welker E, Choate A, et al. Strength of obesity prevention interventions in early care and education settings: a systematic review. *Prev Med*. 2017;95(suppl S37-S52). doi:10.1016/j.ypmed.2016.09.033.				X		
Waters E, de Silva-Sanigorski A, Hall BJ, et al. Interventions for preventing obesity in children. *Cochrane Database Syst Rev.* 2011;(12):CD001871. doi:10.1002/14651858.CD001871.pub3.				X		
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Williams AJ, Henley WE, Williams CA, Hurst AJ, Logan S, Wyatt KM. Systematic review and meta-analysis of the association between childhood overweight and obesity and primary school diet		X		X		

Citation	Outcome	Population	Study Design	Exposure	Not ideal fit for replacement of de novo search	Other
and physical activity policies. *Int J Behav Nutr Phys Act.* 2013;10:101. doi:10.1186/1479-5868-10-101.						
Williams AJ, Wyatt KM, Hurst AJ, Williams CA. A systematic review of associations between the primary school built environment and childhood overweight and obesity. *Health Place*. 2012;18(3):504-514. doi:10.1016/j.healthplace.2012.02.004.		X		X		
Wolfenden L, Jones J, Williams CM, et al. Strategies to improve the implementation of healthy eating, physical activity and obesity prevention policies, practices or programmes within childcare services. 2016;(10):CD011779.						
Workman M, McDade TW, Adair LS, Kuzawa CW. Slow early growers have more muscle in relation to adult activity: evidence from Cebu, Philippines. *Eur J Clin Nutr*. 2015;69(12):1350-1355. doi:10.1038/ejcn.2015.18.	X	X				
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Wu Y, Lau BD, Bleich S, et al. Future research needs for childhood obesity prevention programs: identification of future research needs from comparative effectiveness. *AHRQ Future Research Needs Papers.* No. 31. Rockville, MD: Agency for Healthcare Research and Quality;2013.			X			
Xu J, Lombardi G, Jiao W, Banfi G. Effects of exercise on bone status in female subjects, from young girls to postmenopausal women: an overview of systematic reviews and meta-analyses. *Sports Med.* 2016;46(8):1165-1182. doi:10.1007/s40279-016-0494-0.				X		
Yildirim M, van Stralen MM, Chinapaw MJ, et al; Energy Consortium. For whom and under what circumstances do school-based energy balance behavior interventions work? Systematic review on moderators. *Int J Pediatr Obes.* 2011;6(2-2):e46-e57. doi:10.3109/17477166.2011.566440.				X		
Zeng N, Gao Z. Exergaming and obesity in youth: current perspectives. *Int J Gen Med*. 2016;9:275-284. doi:10.2147/IJGM.S99025.				X		
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Rationale for Exclusion at Abstract or Full-Text Triage for Original Research

The table below lists the excluded articles with at least one reason for exclusion, but may not reflect all possible reasons.

Citation	Outcome	Population	Study Design	Exposure	Other
IOF Regionals: 5th Asia-Pacific Osteoporosis Meeting. *Osteoporosis International*. 2014;25(5 suppl. 1):583-652. doi:10.1007/s00198-014-2892-1.			X		
Csukas A, Takai S, Baran S. Adolescent growth in main somatometric traits of Japanese boys: Ogi Longitudinal Growth Study. *Homo*. 2006;57(1):73-86.				X	
Kwon S, Burns TL, Levy SM, Janz KF. Breaks in sedentary time during childhood and adolescence: Iowa bone development study. *Med Sci Sports Exerc*. 2012;44(6):1075-1080. doi:10.1249/MSS.0b013e318245ca20.	X				
Kwon S, Janz KF, Letuchy EM, Burns TL, Levy SM. Developmental trajectories of physical activity, sports, and television viewing during childhood to young adulthood: Iowa Bone Development Study. *JAMA Pediatr*. 2015;169(7):666-672. doi:10.1001/jamapediatrics.2015.0327.	X				
Murphy NM, Ni Dhuinn M, Browne PA, Orathaille MM. Physical activity for bone health in inactive teenage girls: is a supervised, teacher-led program or self-led program best? *J Adolesc Health*. 2006;39(4):508-514.				X	
Sardinha LB, Baptista F, Ekelund U. Objectively measured physical activity and bone strength in 9-year-old boys and girls. Pediatrics. 2008 Sep;122(3):e728-36. doi: 10.1542/peds.2007-2573			X		
Vicente-Rodriguez G, Ortega FB, Rey-Lopez JP, et al. Extracurricular physical activity participation modifies the association between high TV watching and low bone mass. *Bone*. 2009;45(5):925-930. doi:10.1016/j.bone.2009.07.084.			X		

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2. Carson V, Hunter S, Kuzik N, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth: an update. *Appl Physiol Nutr Metab*. 2016;41(6 suppl 3):S240-S265. doi:10.1139/apnm-2015-0630.

3. Chinapaw MJ, Proper KI, Brug J, van Mechelen W, Singh AS. Relationship between young peoples' sedentary behaviour and biomedical health indicators: a systematic review of prospective studies. *Obes Rev*. 2011;12(7):e621-e632. doi:10.1111/j.1467-789X.2011.00865.x.

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5. Azevedo LB, Ling J, Soos I, Robalino S, Ells L. The effectiveness of sedentary behaviour interventions for reducing body mass index in children and adolescents: systematic review and meta-analysis. *Obes Rev*. 2016;17(7):623-635. doi:10.1111/obr.12414.

6. Wu L, Sun S, He Y, Jiang B. The effect of interventions targeting screen time reduction: a systematic review and meta-analysis. *Medicine (Baltimore)*. 2016;95(27):e4029. doi:10.1097/MD.0000000000004029.

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8. Pate RR, O'Neill JR, Liese AD, et al. Factors associated with development of excessive fatness in children and adolescents: a review of prospective studies. *Obes Rev*. 2013;14(8):645-658. doi:10.1111/obr.12035.

9. Gabel L, Macdonald HM, Nettlefold L, McKay HA. Physical activity, sedentary time, and bone strength from childhood to early adulthood: a mixed longitudinal HR-pQCT study. *J Bone Miner Res*. 2017;32(7):1525-1536. doi:10.1002/jbmr.3115.

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