EVIDENCE PROFILES PREPARED FOR THE 2020 WHO GUIDELINES ON PHYSICAL ACITVITY A ND SEDENTARY BEHAVIOUR FOR CHILDREN AND ADOLESCENTS, ADULTS AND OLDER ADULTS

Background

The information provided in this report was prepared by Carrie D. Patnode (Phd, MPH) and Michelle L. Henninger (PhD), of the Center for Health Research, Kaiser Permanente. It is intended to help the WHO Guideline Development Group (GDG) update the WHO Global Recommendations on Physical Activity for Health *(1)*.

Methods

The GDG decided on the scope of the guideline and PICO (Population, Intervention, Comparison, Outcome) questions as detailed in each section.

Search and Selection Strategy

The update of the WHO global recommendations for children and adolescents builds on work completed for the 2016 *Canadian 24-Hour Movement Guidelines for Children and Youth (2-4)*, the 2018 *Physical Activity Guidelines for Americans, 2nd Edition (5)*, and the 2019 *Australian 24-Hour Movement Guidelines for Children and Young People (5-17 years) (6)*.

The update of the WHO global recommendations for adults and older adults builds on work completed for the 2018 *Physical Activity Guidelines for Americans, 2nd Edition (5)*.

The recommendations for pregnant women builds on work completed for the 2019 *Canadian Guideline for Physical Activity Throughout Pregnancy (2)*.

In order to identify additional applicable evidence, a search for existing systematic reviews was conducted for reviews published from 2017 up to September 2019. The search strategies were adapted from the searches of the US Physical Activity Guidelines Advisory Committee report and Canadian guideline group as appropriate.

The following databases were searched for the Canadian update: MEDLINE, EMBASE, PsycInfo, and SportDiscus to identify reviews that were peer-reviewed, written in English or French.

The following databases were searched for the US update: PubMed, CINAHL, and Cochrane to identify reviews that were peer-reviewed, written in English with no restriction on country or country income group.

Independent teams of reviewers reviewed all citations and relevant full-text articles to identify existing systematic reviews that addressed one or more of the PICO questions. Details from each eligible review were extracted into standardized forms. Reviews were then categorized according to the behavior(s) (physical activity and/or sedentary behaviour) and outcomes reported.

Rating the Credibility of Existing Systematic Reviews

An external team of reviewers used the AMSTAR 2 (Assessment of Multiple Systematic Reviews) instrument to rate the credibility of the systematic reviews under consideration for inclusion *(7)*. The AMSTAR 2 tool contains 16 items that relate to the planning and conduct of the review. The overall confidence in the results of each review was rated according to published guidance: a rating of "high" reflects that the review had zero or one noncritical weakness; "moderate" indicates the review was judged to have more than one noncritical weakness; "low" means the review was judged to have one critical flaw with or without noncritical weaknesses or multiple noncritical weaknesses; and "critically low" signifies that more than one critical flaw was present. One reviewer completed the AMSTAR 2 tool for all provisionally included reviews. Reviews that were rated critically low by one reviewer were dual reviewed by a second reviewer using the same tool. Reviews ultimately rated as critically low were excluded because they were judged to not provide an accurate and comprehensive summary of the available evidence.

This body of evidence also included pooled cohort studies. An external team of reviewers used the Newcastle-Ottawa Scale to assess the quality of those studies *(4)*. Each study was given a quality rating of good, fair, or poor quality. In general, a good-quality study met all criteria. A fair-quality study did not meet, or it was unclear whether it met at least one criterion, but also had no known important limitations that could invalidate its results. A poor-quality study had a single fatal flaw or multiple important limitations. Poor-quality studies were excluded from this report.

Grading the Body of Evidence

The Grading of Recommendations Assessment, Development and Evaluation (GRADE) method was used to rate the certainty of the evidence for each PICO *(8)*. When available, the GRADE "Evidence Profiles" or "Summary of Findings" tables from each review were used as a starting point. If no table was available within the existing systematic reviews, Evidence Profile tables for each population and outcome of interest were constructed.

The GRADE method was used to rate the certainty of the evidence for each PICO *(5)* with the following criteria considered: study design, risk of bias, consistency of effect, indirectness, precision of effect, and other limitations, including publication bias and other factors for upgrading (magnitude of effect, dose-response, and effects of confounders). We upgraded well-conducted longitudinal studies to better reflect the certainty in findings regarding associations from such studies. We did not necessarily downgrade studies that evaluated intermediate/indirect outcomes; the GRADE rating reflects the certainty in effects on those outcomes. In some cases, the GRADE ratings from existing reviews were modified to ensure consistency in how GRADE methods were applied. The certainty in the body of evidence for each outcome was assigned based on the following guidance
(6):

High	We are very confident that the true effect lies close to that of the estimate of the effect
Moderate	We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different
Low	Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect
Very low	We have very little confidence in the effect estimate: The true effect is likely to be substantially different from the estimate of effect.

The GRADE Evidence Profiles developed for the update of the 2019 *Australian 24-Hour Movement Guidelines for Children and Young People (5-17 years) (6)* were used as a basis for this update for children and adolscents, given the rigor in methods and recency in included evidence. The following modifications were made to the GRADE assessments from the Australian guideline: 1) evidence from observational studies evaluating associations was upgraded one level if the studies were well-conducted longitudinal studies with no serious risk of bias, to better reflect the certainty in findings regarding associations from such studies and 2) evidence from all studies was downgraded one level if there was only one study, due to inability to assess consistency. The development of the Australian guideline utilized the GRADE-ADOLOPMENT approach, leveraging the work done in Canada in the development of their 24-hour guidelines *(3, 4)*. Therefore, this work builds upon the Evidence Profiles developed by Canada and Australia. For each PICO, identified systematic reviews were incorporated into the existing Evidence Profiles according to the study designs included in the review. A summary of findings for each review is provided. In cases where the identified systematic reviews suggested differences in the quality assessment (risk of bias, inconsistency, indirectness, imprecision, or other risk of bias) or overall certainty, the evidence profiles were edited accordingly. Additional evidence and conclusions of the US Physical Activity Guidelines Advisory Committee report were included in the draft Evidence Profiles to contextualize the overall body of evidence.

A: Evidence on physical activity and sedentary behaviour for children and adolescents (5 to under 18 years of age)

Guiding Questions

A1. What is the association between **physical activity** and health-related outcomes?
   a. Is there a dose-response association (volume, duration, frequency, intensity)?
   b. Does the association vary by type or domain of physical activity?

A2. What is the association between **sedentary behaviour** and health-related outcomes?

a. Is there a dose-response association (total volume and the frequency, duration and intensity of interruption)?
b. Does the association vary by type and domain of sedentary behaviour?

Inclusion Criteria

Population: Children aged 5 – under 18 years of age
Exposure: Greater volume, duration, frequency or intensity of physical activity; greater volume, decreased frequency, duration or intensity of interruption of sedentary behaviour.
Comparison: No physical activity or lesser volume, duration, frequency, or intensity of physical activity; lesser volume, increased frequency, duration or intensity of interruption of sedentary behaviour.

Outcomes	Importance
Physical fitness (e.g. cardiorespiratory, motor development, muscular fitness)	Critical
Cardiometabolic health (e.g. blood pressure, dyslipidaemia, glucose, insulin resistance)	Critical
Bone health	Critical
Adiposity	Critical
Adverse effects (e.g. injuries and harms, respiratory effects of air pollution)	Critical
Mental health (e.g. depressive symptoms, self-esteem, anxiety symptoms, ADHD)	Critical
Cognitive outcomes (e.g. academic performance, executive function)	Critical
Prosocial behaviour (e.g. conduct problems, peer relations, social inclusion)	Important
Sleep duration and quality	Important

Included Evidence

Twenty-one reviews were identified (published from 2017 to 2019) that examined the association between physical activity and/or sedentary behaviour and health-related outcomes among children and adolescents *(9-29)*. Fourteen reviews examined the relationship between physical activity and health-related outcomes, five reviews examined the relationship between sedentary behaviour and health-related outcomes, and two reviews included both physical activity and sedentary behaviour (**Table 1.1**). The most commonly reported outcomes in the reviews were measures of adiposity and cardiometabolic health. No reviews were identified that evaluated the association between physical activity and adverse effects, mental health outcomes, or sleep outcomes and no reviews were identified that evaluated the association between sedentary behavior and physical fitness, adverse effects, cognitive outcomes, or prosocial behavior. Furthermore, none of the existing reviews robustly examined whether there was a dose-response association between physical activity or sedentary behaviour and health-related outcomes, whether the association varied by type or domain of physical activity or sedentary behaviour, and whether physical activity modified the effect of sedentary behaviour on mortality. In most cases, each review was narrowly scoped to look at specific types of physical activity (e.g., high-intensity interval training, school-based physical activity programs) or sedentary behavior (e.g., objectively-measured sedentary time) and limited inclusion to specific study designs (e.g., only randomized controlled trials).

Few reviews (three) included evidence published into 2019. About half of the reviews included evidence published from database inception through at least 2017; seven reviews searched through 2014, 2015, or 2016 and three reviews did not report search dates. Extracted data for each review is included in **Appendix 1A.**

None of the systematic reviews were rated as having high credibility based on the AMSTAR 2 instrument. Six were rated as having moderate credibility, 10 were rated as having low credibility, and 5 were rated as having critically low credibility. Given concerns regarding the comprehensiveness and the validity of the results presented in reviews rated as having very low credibility, they were not incorporated into the final Evidence Profiles. **Table 1.2** presents the ratings for each review according to all the AMSTAR 2 main domains.

Table 1.1. Included Systematic Reviews

Author, Year	Behavior		Outcomes									Last search date	# of included studies	AMSTAR 2
	PA	SB	Physical fitness	CM health	Bone health	Adip-osity	AEs	Mental health	Cognitive outcomes	Prosocial behavior	Sleep duration and quality			
Bea, 2017 *(9)*	X			X								2015	13	Moderate
Belmon, 2019 *(10)*		X									X	Jan 2017	45	Low
Cao, 2019 *(11)*	X		X									Feb 2019	17	Low
Collins, 2018 *(12)*	X					X						June 2017	18	Low
Eddolls, 2017 *(13)*	X			X		X						Sept 2016	13	Low
Errisuriz, 2018 *(14)*	X		X			X						NR	12	Critically Low
Fang, 2019 *(15)*		X				X						May 2019	16	Low
Koedijk, 2017 *(16)*		X			X							Jan 2019	17	Moderate
Krahenbühl, 2018 *(17)*	X				X							2016	21	Critically Low
Lee, 2018 *(18)*	X					X						Jan 2014	27	Critically Low
Marker, 2019 *(19)*		X				X						June 2018	24	Low
Marques, 2018 *(20)*	X								X			2016	51	Moderate
Martin, 2017 *(21)*	X					X			X			Mar 2015	15	Moderate
Miguel-Berges, 2018 *(22)*	X					X						July 2015	36	Low
Mohammadi, 2019 *(23)*	X	X				X						Aug 2017	17	Low
Pozuelo-Carrascosa, 2018 *(24)*	X			X								Feb 2018	19	Moderate
Singh, 2019 *(25)*	X								X	X		Sept 2017	58	Critically Low
Skrede, 2019 *(26)*	X	X		X								April 2018	30	Critically Low
Stanczykiewicz, 2019 *(27)*		X						X				NR	31	Low
Verswijveren, 2018 *(28)*	X			X								2017	29	Moderate
Xue, 2019 *(29)*	X								X			NR	19	Low

Abbreviations: AEs = adverse effects; CM = cardiometabolic; PA = physical activity; SB = sedentary behavior

Table 1.2. Credibility Ratings (AMSTAR 2)

Author, Year	PICO[1]	A priori Methods[2]	Study Design Selection[3]	Search Strategy[4]	Study Selection[5]	Data Extraction[6]	Excluded Studies[7]	Included Studies[8]	RoB Assess-ment[9]	Funding Sources[10]	Statistical Methods[11]	Impact of RoB[12]	RoB Results[13]	Heterogeneity[14]	Publication Bias[15]	COI[16]	Overall Rating[17]
Bea, 2017 *(9)*	Y	N	N	PY	Y	Y	PY	PY	Y	N	N/A	N/A	Y	N	N/A	Y	**Moderate**
Belmon, 2019 *(10)*	Y	N	N	PY	Y	Y	PY	PY	N	N	N/A	N/A	Y	N	N/A	Y	**Low**
Cao, 2019 *(11)*	Y	N	N	PY	Y	Y	PY	Y	N	N	Y	Y	N	Y	Y	Y	**Low**
Collins, 2018 *(12)*	Y	N	N	PY	Y	Y	N	Y	PY	N	Y	Y	Y	Y	Y	Y	**Low**
Eddolls, 2017 *(13)*	Y	N	N	PY	N	N	PY	N	Y	N	N/A	N/A	Y	Y	N/A	Y	**Low**
Errisuriz, 2018 *(14)*	Y	N	N	N	Y	Y	PY	PY	N	N	N/A	N/A	N	N	N/A	Y	**Critically Low**
Fang, 2019 *(15)*	Y	N	N	PY	Y	N	PY	PY	Y	N	N	N	N	Y	Y	Y	**Low**
Koedijk, 2017 *(16)*	Y	N	N	PY	Y	Y	Y	PY	PY	N	N/A	N/A	Y	Y	N/A	Y	**Moderate**
Krahenbühl, 2018 *(17)*	Y	N	N	PY	N	N	PY	PY	N	N	N/A	N/A	N	N	N/A	Y	**Critically Low**
Lee, 2018 *(18)*	Y	N	N	PY	Y	Y	N	PY	N	N	N/A	N/A	N	Y	N/A	N	**Critically Low**
Marker, 2019 *(19)*	Y	N	N	PY	N	Y	PY	N	N	N	Y	Y	N	Y	Y	Y	**Low**
Marques, 2018 *(20)*	Y	N	N	PY	Y	Y	PY	PY	PY	N	N/A	N/A	Y	Y	N/A	Y	**Moderate**
Martin, 2017 *(21)*	Y	N	N	PY	Y	N	PY	Y	Y	N	N/A	N/A	Y	N	N/A	N	**Moderate**
Miguel-Berges, 2018 *(22)*	Y	N	N	PY	Y	Y	Y	PY	Y	Y	N/A	N/A	N	N	NA	N	**Low**
Mohammadi, 2019 *(23)*	Y	N	N	PY	Y	Y	PY	PY	PY	N	N/A	N/A	Y	Y	N/A	Y	**Low**
Pozuelo-Carrascosa, 2018 *(24)*	Y	N	N	PY	Y	Y	PY	Y	Y	N	Y	N	Y	Y	Y	Y	**Moderate**
Singh, 2019 *(25)*	Y	N	N	PY	Y	Y	N	PY	PY	N	N/A	N/A	Y	Y	N/A	Y	**Critically Low**
Skrede, 2019 *(26)*	Y	N	N	N	Y	N	PY	PY	N	N	N	N	N	N	N/A	Y	**Critically Low**
Stanczykiewicz, 2019 *(27)*	Y	N	N	Y	Y	Y	PY	Y	PY	N	Y	N	Y	Y	Y	Y	**Low**
Verswijveren, 2018 *(28)*	Y	N	N	PY	Y	Y	PY	PY	PY	N	N/A	N/A	Y	Y	N/A	Y	**Moderate**
Xue, 2019 *(29)*	Y	N	N	PY	Y	N	PY	Y	PY	N	N	N	N	Y	Y	Y	**Low**

Abbreviations: COI = conflict of interest; N = no; PICO = population, intervention, comparator, outcome; PY = partial yes; RoB = risk of bias; CM = cardiometabolic; PA = physical activity; SB = sedentary behavior; Y = yes

[1] Did the research questions and inclusion criteria for the review include the components of PICO?
[2] Did the report of the review contain an explicit statement that the review methods were established prior to the conduct of the review and did the report justify any significant deviations from the protocol?
[3] Did the review authors explain their selection of the study designs for inclusion in the review?
[4] Did the review authors use a comprehensive literature search strategy?
[5] Did the review authors perform study selection in duplicate?
[6] Did the review authors perform data extraction in duplicate?
[7] Did the review authors provide a list of excluded studies and justify the exclusions?
[8] Did the review authors describe the included studies in adequate detail?
[9] Did the review authors use a satisfactory technique for assessing the risk of bias (RoB) in individual studies that were included in the review?
[10] Did the review authors report on the sources of funding for the studies included in the review?
[11] If meta-analysis was performed did the review authors use appropriate methods for statistical combination of results?
[12] If meta-analysis was performed, did the review authors assess the potential impact of RoB in individual studies on the results of the meta-analysis or other evidence synthesis?
[13] Did the review authors account for RoB in individual studies when interpreting/ discussing the results of the review?
[14] Did the review authors provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results of the review?
[15] If they performed quantitative synthesis did the review authors carry out an adequate investigation of publication bias (small study bias) and discuss its likely impact on the results of the review?
[16] Did the review authors report any potential sources of conflict of interest, including any funding they received for conducting the review?
[17] Shea et al. 2017. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. *(7)*

A.1. Physical Activity

Table A.1.a. Physical fitness and physical activity, children and adolescents

Questions: What is the association between **physical activity** and health-related outcomes? Is there a dose response association (volume, duration, frequency, intensity)? Does the association vary by type or domain of PA?
Population: Children aged 5-under 18 years of age
Exposure: Greater volume, duration, frequency, or intensity of physical activity
Comparison: No physical activity or lesser volume, duration, frequency, or intensity of physical activity
Outcome: Physical fitness (e.g., cardiorespiratory, motor development, muscular fitness)
*__Importance__: CRITICAL

Black font is from original GRADE Evidence Profiles from Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (12-17 years).*(6)* Red font denotes additions based on WHO update using review of existing systematic reviews.

	Quality Assessment							
No. of studies/ Study design **No. of participants**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other**	**Summary of findings**	**Certainty**	**US PAGAC evidence and conclusions *(30)***
The range of mean ages was 6.9 to 16.0 years. Data were collected by RCT, non-randomized intervention trial, cross-sectionally and up to 3.75 years of follow-up. Fitness was assessed as: aerobic fitness (VO2max, VO2peak, CRF), muscular strength, coordination, shoulder mobility and endurance, and flexibility. All outcomes were measured objectively.								
7 RCTs[a] N = 1,483	Serious risk of bias[b]	No serious inconsistency	Serious indirectness[c]	No serious imprecision	None	**Aerobic fitness:** **4 studies** reported a favourable effect of PA interventions on aerobic fitness at post-test (Kriemler et al. 2010; Cohen et al. 2015) and 6-month and 2-year follow-up (Eather et al. 2013; Meyer et al. 2014); **2 studies** reported no effect (Verstraete et al. 2007; Finkelstein et al. 2013).[d] Cao et al. 2019 *(11)* (16 RCTs, 1 NRT; n=563): High-intensity interval training compared with moderate-intensity continuous training had a moderate beneficial effect on cardiorespiratory fitness (SMD = 0.51 [95% CI, 0.33 to 0.69], $p<0.01$; $I^2=0\%$). No evidence that intervention duration, exercise modality, work and rest ratio, and total bouts modified the effect of high-intensity interval training on cardiorespiratory fitness. **Muscular strength and endurance:** **1 study** reported a favourable effect of PA interventions on upper and lower-body muscular fitness at post-test; these differences were no longer significant after 3 months (Meinhardt et al. 2013); **1 study** reported no effect at post-test (Verstraete et al. 2007); **1 study** reported mixed favourable and null findings at 6-month follow	LOW[e]	15 ESRs Strong evidence demonstrates that, in children and adolescents, higher amounts of physical activity are associated with more favorable status for cardiorespiratory and muscular fitness. **PAGAC Grade: Strong** Strong evidence demonstrates that increased moderate-to-vigorous physical

						up (Eather et al. 2013). **No reviews reporting strength and endurance outcomes identified.** **Flexibility:** **1 study** reported no effect at post-test (Verstraete et al. 2007); **1 study** reported a favourable effect of PA on flexibility at 6-month follow-up (Eather et al. 2013). **No reviews reporting flexibility outcomes identified.**		activity increases cardiorespiratory fitness and that increased resistance exercise increases muscular fitness in children and adolescents. **PAGAC Grade: Strong**
8 NRTs[f] N = 5,336 **No reviews limited to NRTs identified.**	Serious risk of bias[g]	No serious inconsistency	Serious indirectness[h]	No serious imprecision	None	**Aerobic Fitness:** **1 study** reported no effect of PA intervention on aerobic fitness (Rowland et al. 1996); **4 studies** reported a favourable effect of PA intervention for INT compared with CTRL (Dimitriou et al. 2011; Buchele 2018;Brusseau et al 2016, Chesham et al. 2018); **1 study** reported mixed effects of PA intervention on aerobic fitness across subsamples at post-test (favourable effect for Grade 6 children but not Grade 1 to 5) (Burns et al. 2017); and **1 study** reported no differential effect of PA intervention on aerobic fitness between INT and CTRL, however the intervention group decreased from baseline to post-test (Shore et al. 2014). **Muscular Strength and Endurance:** **1 study** reported a favourable effect of PA intervention on upper-body strength for INT compared with CTRL (Dimitriou et al. 2011); **1 study** reported a favourable effect of PA intervention on endurance, co-ordination and shoulder mobility (Postler et al 2017); and **1 study** reported no differential effect of PA intervention on muscular fitness, however the control group improved upper-body strength from baseline to post-test (Shore et al. 2014). **Flexibility:** **1 study** reported a favourable differential effect of PA intervention for INT compared with CTRL (Dimitriou et al. 2011). **1 study** reported no differential effect of a PA intervention on flexibility, and an increase from baseline to post-test for the intervention group (Shore et al. 2014).	VERY LOW[i]	
2 Longitudinal[j] N = 630 **No reviews including or limited to longitudinal designs identified.**	No serious risk of bias	No serious inconsistency	No serious indirectness	Serious imprecision[k]	Dose response gradient[l]	**Aerobic fitness:** There was a favourable, dose-response gradient between **VPA** and aerobic fitness, and no association between **LPA** or **MPA** and aerobic fitness in **2 longitudinal studies** (Carson et al. 2014; Santos et al. 2018).	LOW[m]	
48 Cross-sectional[n] N = 14,985 **No reviews including or**	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	**Aerobic fitness:** **Meeting/Not Meeting PA Guidelines (≥60 min/day MVPA):** favourable associations (**3/3 studies;** Ortega et al. 2008; Martinez-Gomez et al. 2010a; Silva et al. 2013). **Total PA:** associations were favourable (**14/18 studies;** Eiberg et al. 2005; Andersen et al. 2006; Ruiz et al. 2006; Butte et al. 2007b; Hands et al. 2009; Schofield et al. 2009; Ruiz et al. 2011; Machado-Rodrigues et al. 2012; Martinez-Gomez et al. 2012;	VERY LOW[u]	

limited to longitudinal designs identified.						Hjorth et al. 2013; Lambourne et al. 2013; Larouche et al. 2014; Hansen et al. 2014; Saavedra et al. 2014), or mixed (favourable and null; **4/18 studies;** Rizzo et al. 2007; Dencker et al. 2010; Kristensen et al. 2010; Jimenez-Pavon et al. 2013c).[o] **VPA:** associations were favourable (**11/12 studies;** Gutin et al. 2005a; Ruiz et al. 2006; Rizzo et al. 2007; Butte et al. 2007b; Lohman et al. 2008; Martinez-Gomez et al. 2010a; Kristensen et al. 2010; Ottevaere et al. 2011; Hay et al. 2012; Martinez-Gomez et al. 2012; Jimenez-Pavon et al. 2013c), or mixed (favourable and null; **1/12 studies;** Dencker et al. 2010).[p] **MVPA:** associations were favourable (**14/16 studies;** Eiberg et al. 2005; Gutin et al. 2005a; Ruiz et al. 2006; Butte et al. 2007b; Ortega et al. 2008; Lohman et al. 2008; Martinez-Gomez et al. 2010a; Ruiz et al. 2011; Ottevaere et al. 2011; Machado-Rodrigues et al. 2012; Martinez-Gomez et al. 2012; Hjorth et al. 2013; Silva et al. 2013; Santos et al. 2014), or mixed (favourable in boys, null in girls; **2/16 studies;** Dencker et al. 2010; Jimenez-Pavon et al. 2013c).[q] *Bouts of MVPA* were favourably associated with aerobic fitness in **2/2 studies** (Eiberg et al. 2005; Butte et al. 2007b). **MPA:** associations were favourable (**5/9 studies;** Gutin et al. 2005a; Ruiz et al. 2006; Martinez-Gomez et al. 2010; Dencker et al. 2010; Ottevaere et al. 2011), mixed favourable and null (**2/9 studies;** Rizzo et al. 2007; Butte et al. 2007b), or null (**2/9 studies;** Hay et al. 2012; Martinez-Gomez et al. 2012).[r] **LPA:** associations were favourable (**1/6 studies;** Martinez-Gomez et al. 2010a), mixed favourable and null (**1/6 studies;** Butte et al. 2007b), or null (**4/6 studies;** Dencker et al. 2010; Hay et al. 2012; Machado-Rodrigues et al. 2012; Jimenez-Pavon et al. 2013c). **Muscular Strength and Endurance** **Total PA:** associations were favourable (**2/4 studies;** Martinez-Gomez et al. 2012; Larouche et al. 2014), mixed favourable and null (**1/4 studies;** Hands et al. 2009), or null (**1/4 studies;** Moliner-Urdiales et al. 2010).[s] **VPA:** associations were favourable (**1/2 studies;** Martinez-Gomez et al. 2012), or mixed favourable and null (**1/2 studies;** Moliner-Urdiales et al. 2010). **MVPA:** associations were favourable (**1/3 studies;** Martinez-Gomez et al. 2012), or mixed favourable and null (**2/3 studies;** Moliner-Urdiales et al. 2010; Aggio et al. 2015).[t] **MPA:** null associations (**2/2 studies;** Moliner-Urdiales et al. 2010; Martinez-Gomez et al. 2012). **LPA:** associations were null (**1/2 studies;** Moliner-Urdiales et al. 2010), or mixed null and unfavourable (**1/2 studies;** Aggio et al. 2015). **Flexibility**		

						Total PA: associations were mixed favourable and null (**1/2 studies;** Hands et al. 2009) or null (**1/2 studies;** Larouche et al. 2014). **MVPA:** favourable associations (**1/1 studies;** Aggio et al. 2015). **LPA:** null associations (**1/1 studies;** Aggio et al. 2015).		

Abbreviations: CRF = cardiorespiratory fitness; ESR = existing systematic review; LPA = light physical activity; MVPA = moderate-to-vigorous physical activity; NRT = non-randomized trial; PA = physical activity; RCT = randomized controlled trial; VO_2max = maximal oxygen uptake; VO_2peak = peak oxygen uptake; VPA = vigorous physical activity.

[*] As determined by WHO

[a] Includes **6 RCT studies** (Verstraete et al. 2007; Kriemler et al. 2010; Meinhardt et al. 2013; Finkelstein et al. 2013; Eather et al. 2013; Meyer et al. 2014) from **5 unique samples**. Kriemler et al. 2010 and Meyer et al. 2014 both report data from the KISS Study. Results are reported separately, and participants are only counted once.

[b] Serious risk of bias. Unclear method of randomization for sibling pairs; allocation concealment unlikely; missing pedometer data disproportionately high in controls relative to intervention group (18.1% vs 6.1%), likely due to incentives for wear time offered to the intervention group only; control group wore sealed pedometers while intervention group wore unsealed pedometers; 6-min walk test assessors were not blinded to group assignment (Finkelstein et al. 2013). No allocation concealment, which was likely to contaminate the control group (Meinhardt et al. 2013). Teachers of control group classes were aware of intervention arm but not its content; drop-outs were older and had higher adiposity than adherers and differences likely to be related to outcome of interest (Meyer et al. 2014).

[c] Serious indirectness. Differences in intervention: randomized trials examined various types of physical activity programs and provided indirect evidence bearing on the potential effectiveness of different intensities and durations of physical activity. Indirect comparisons: different durations and intensities of physical activity were not compared.

[d] MVPA (but not total PA) was significantly greater in the intervention vs control group at post-intervention (post 9-month intervention group difference of ~11 min/day) (Kriemler et al. 2010); there was a trend toward higher levels of total PA (but not MVPA) in the intervention vs control group at 3-yr follow-up (Cohen's $d = 0.35$, $p=0.06$; not significant) (Meyer et al. 2014).

[e] The quality of evidence from randomized studies was downgraded from "high" to "low" due to: (1) a serious risk of bias in three studies that diminished the level of confidence in the observed effects, and (2) serious indirectness of the interventions and the comparisons being assessed.

[f] Includes **1 non-randomized controlled trial** (Shore et al. 2014), **1 community trial** (Dimitriou et al. 2011), and **1 uncontrolled trial** (Rowland et al. 1996).

[g] Serious risk of bias. No inclusion/exclusion criteria established; inadequate reporting of recruitment, allocation concealment, and blinding; large unexplained loss to follow-up (36.5% retention) and unknown if follow-up differed by group allocation (Shore et al. 2014); selective reporting bias: reported use of PACER to measure aerobic fitness but did not report in results (Dimitriou et al. 2011).

[h] Serious indirectness. Differences in intervention: non-randomized trials examined various types of physical activity programs and provided indirect evidence bearing on the potential effectiveness of different intensities and durations of physical activity. Indirect comparisons: different durations and intensities of physical activity were not compared.

[i] The quality of evidence from randomized studies was downgraded from "high" to "low" due to: (1) a serious risk of bias in two studies that diminished the level of confidence in the observed effects, and (2) serious indirectness of the interventions and the comparisons being assessed.

[j] Includes **1 longitudinal study** (Carson et al. 2014).

[k] Serious imprecision. Wide confidence intervals for dose-response trend (Carson et al. 2014).

[l] There was a positive, dose-response gradient between VPA and aerobic fitness (Carson et al. 2014).

[m] The quality of evidence from the longitudinal study was upgraded from "low" to "moderate" due to no serious risk of bias but downgraded from "moderate" to "low" due to imprecision (wide confidence intervals), and because of this limitation was not upgraded for the dose-response trend.

[n] Includes **28 cross-sectional studies** (Eiberg et al. 2005; Gutin et al. 2005a; Andersen et al. 2006; Ruiz et al. 2006; Rizzo et al. 2007; Butte et al. 2007b; Ortega et al. 2008; Lohman et al. 2008; Hands et al. 2009; Schofield et al. 2009; Martinez-Gomez et al. 2010a; Dencker et al. 2010; Kristensen et al. 2010; Moliner-Urdiales et al. 2010; Ruiz et al. 2011; Ottevaere et al. 2011; Hay et al. 2012; Machado-Rodrigues et al. 2012; Martinez-Gomez et al. 2012; Hjorth et al. 2013; Lambourne et al. 2013; Silva et al. 2013; Jimenez-Pavon et al. 2013c; Larouche et al. 2014; Santos et al. 2014; Hansen et al. 2014; Saavedra et al. 2014; Aggio et al. 2015) from **17 unique samples**. **Five studies** report data from the EYHS (Andersen et al. 2006, Ruiz et al. 2006; Ortega et al. 2008; Rizzo et al. 2008; Kristensen et al. 2010); **6 studies** report data from HELENA (Martinez-Gomez et al. 2010a; Moliner-Urdiales et al. 2010; Ottevaere et al. 2011; Ruiz et al. 2011; Martinez-Gomez et al. 2012; Jimenez-Pavon et al. 2013c); **2 studies** report data from the CoSCIS study (Eiberg et al. 2005; Dencker et al. 2010). Data are reported separately, and participants are only counted once.

[o] Positive associations between Total PA and aerobic fitness were found in the total sample (Eiberg et al. 2005; Andersen et al. 2006; Ruiz et al. 2006; Rizzo et al. 2007; Ruiz et al. 2011; Martinez-Gomez et al. 2012), in boys but not girls (Dencker et al. 2010; Jimenez-Pavon et al. 2013c), and in 9 year olds but not 15 year olds (Kristensen et al. 2010).

[p] Dencker et al. (2010) reported a positive association between VPA and aerobic fitness for boys, but not girls.

[q] Positive associations were reported between MVPA and aerobic fitness in the total sample (Eiberg et al. 2005; Martinez-Gomez et al. 2010a; Ruiz et al. 2011; Ottevaere et al. 2011; Martinez-Gomez et al. 2012) , and in boys but not girls in subdivided samples (Dencker et al. 2010; Jimenez-Pavon et al. 2013b).

[r] From the HELENA cohort, Martinez-Gomez et al. (2010a) and Ottevaere et al. (2011) reported positive associations for MPA and aerobic fitness in total sample, Martinez-Gomez et al. (2012) reported a null association, and Jimenez Pavon et al. (2013c) reported a positive association for boys, not girls. From the Viva la Familia study, Butte et al. (2007b) reported positive associations when controlling for BMI z-score but not %FM.

[s] Total PA was positively associated with standing broad jump and not associated with upper body- and other lower body strength and endurance in boys, and not associated with any muscular fitness outcome in girls (Moliner-Urdiales et al. 2010); No correlation with abdominal muscle endurance (curl-ups) or upper body strength, but high tertiles of total PA had better upper body strength (grip strength) (Hands et al. 2009).

[t] MVPA was positively associated with lower body strength but not upper body strength in one study (Aggio et al. 2015), and not associated with upper and lower body strength in boys and girls, with the exception of a positive association for standing broad jump for boys (Moliner-Urdiales et al. 2010).

[u] The quality of evidence from cross-sectional studies remained as "low" as there were no serious concerns about the quality of studies or reasons to rate-up.

Table A.1.b. Cardiometabolic health and physical activity, children and adolescents

Questions: What is the association between **physical activity** and health-related outcomes? Is there a dose response association (volume, duration, frequency, intensity)? Does the association vary by type or domain of PA?
Population: Children aged 5-under 18 years of age
Exposure: Greater volume, duration, frequency, or intensity of physical activity
Comparison: No physical activity or lesser volume, duration, frequency, or intensity of physical activity
Outcome: Cardiometabolic health (e.g., blood pressure, dyslipidaemia, glucose, insulin resistance)
*__Importance__: CRITICAL

Black font is from original GRADE Evidence Profiles from Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (12-17 years).*(6)* Red font denotes additions based on WHO update using review of existing systematic reviews.

	Quality Assessment							
No. of studies/ Study design **No. of participants**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other**	**Summary of findings**	**Certainty**	**US PAGAC evidence and conclusions** *(30)*
The range of mean ages was 5.1 to 17.0 years. Data were collected by RCT, non-randomized intervention trial, cross-sectionally and up to 4 years of follow-up. Cardiometabolic biomarkers assessed were: blood pressure (systolic BP, diastolic BP, mean arterial BP, pre-high BP, high BP, hypertension), blood lipids (TG, HDL, LDL, total cholesterol), insulin sensitivity/resistance (HOMA, HOMA-%S; QUICKI, Matsuda index), fasting insulin and glucose, oral glucose tolerance test results (2-hr plasma glucose, AUC I/G$_{t30\ min}$, AUC I/G$_{t120min}$), HbA1c, RPP, inflammatory markers (CRP, IL-6, TNF-α, C3, C4), artery properties (PWV, carotid intima-media thickness, carotid compliance, Young's elastic modules, stiffness index), ALT, cardiac sympathetic-parasympathetic modulation, homocysteine, liver fat & GGT (y-glutamyl transferase) and composite cardiometabolic risk scores. All outcomes were measured objectively.								
2 RCTs[a] N = 502	No serious risk of bias Serious risk of bias	No serious inconsistency	Serious indirectness[b]	No serious imprecision Serious imprecision	None Outcomes were variably reported Limited to laboratory-based PA	The intervention group had larger reductions in **TGs**, **glucose**, and **cardiometabolic disease risk score** and a greater increase in **HDL** vs the control group. **Systolic BP** and **diastolic BP** were not different between groups (Kriemler et al. 2010).[c] There were no differences in **glucose, HDL**, **TG,** or **systolic BP** or **diastolic BP** between the control and intervention groups 3-yr post-intervention (Meyer et al. 2014).[c] Three reviews examined the effectiveness of high-intensity interval training *(13)*, resistance training *(9)*, and school-based PA programs *(24)* versus no intervention on measures of cardiometabolic health. Within all 3 reviews, there was consistent evidence that interventions were associated with better cardiometabolic outcome measures, however; there was varied precision in effect sizes and few individual trials found statistically significant benefit of physical activity across all cardiometabolic outcomes. Eddolls et al. 2017 *(13)* (13 RCTs; n=1,899): High-intensity interval training was associated with improvements in **systolic and diastolic BP** but only 2 of 5 RCTs reporting BP found these improvements to be statistically significantly different from	MODERATE[d]	9 ESRs Moderate evidence indicates that physical activity is positively associated with cardiometabolic health in children and adolescents. **PAGAC Grade: Moderate** Moderate evidence indicates that physical activity is positively associated with cardiometabolic health in children and adolescents in general; the evidence

						moderate-intensity training or other control groups. Four RCTs examined effects of high-intensity interval training on **glucose** (4 trials), **total cholesterol** (2 trials), **HDL** (3 trials), **LDL** (1 trial), **TG** (3 trials), and **insulin** (1 trial) and all reported improvements (with 3/4 finding differences to be statistically significant) following high-intensity training vs. moderate-intensity training (6-12 weeks). Bea et al. 2017 *(9)* (13 RCTs; n=1,134): Few studies found statistically significant positive effects of resistance training versus no resistance training on measures of cardiometabolic health. Pozuelo-Carrascosa et al. 2018 *(24)* (19 RCTs; n=11,988): School-based PA programs were associated with statistically significant improvements in **diastolic BP** (ES = -0.21 [95% CI, -0.42 to -0.01]; p=0.4) and **fasting insulin** (ES = -0.12 [95% CI, -0.42 to -0.04]; p=0.03) compared with no physical activity interventions. There was no improvement in **fasting glucose** (ES = -0.06 [95% CI, -1.28 to 0.08]; p=0.085), **systolic BP** (ES = -0.14 [95% CI, -0.31 to 0.03]; p=0.11), **HDL** (ES = -0.09 [95% CI, -0.05 to 0.23]; p=0.15); **LDL** (ES = -0.23 [95% CI, -0.52 to 0.07]; p=0.13), **TG** (ES = 0.02 [95% CI, 0.11 to 0.15]; p=0.77); or **TC** (ES = -0.03 [95% CI, -0.37 to 0.31]; p=0.86) when comparing school-based PA interventions versus no PA interventions.		is strong for plasma TG and insulin. **PAGAC Grade: Moderate**
2 NRT[e] N = 71 **No reviews limited to NRTs identified.**	Serious risk of bias[f]	No serious inconsistency	Serious indirectness[g]	No serious imprecision	None	There were significant intervention effects on **systolic BP**, **total cholesterol & fasting glucose** (Aires et al. 2015). Aerobic training had no effect on **total cholesterol**, **HDL** or **TG**. In boys, **LDL** decreased during the control weeks prior to the intervention (Rowland et al. 1996).[h]	VERY LOW[i]	
15 Longitudinal[j] **No reviews including or limited to longitudinal designs identified.**	Serious risk of bias[k]	No serious inconsistency	No serious indirectness	No serious imprecision	None	***Meeting/Not Meeting Guidelines:*** Changes in *PA guideline adherence* over 2-yr did not influence incidence of **pre-high BP** or **high-BP** (de Moraes et al. 2015).[l] 1 study showed favourable effect with meeting the PA guidelines on BP (deMoraes et al. 2014). ***Total PA:*** **Systolic BP:** null association (**2/2 studies;** Hallal et al. 2011; Knowles et al. 2013); **Diastolic BP:** associations were favourable (**1/2 studies;** Knowles et al. 2013), or mixed (favourable and null; compared with the *least active tercile,* children in the *most active tercile* of PA at age 12 yr had lower diastolic BP at age 14; no difference between least active and intermediate terciles; **1/1 studies;** Hallal et al. 2011); **Mean arterial BP:** null association (**2/2 studies;** Hjorth et al. 2014a; Macdonald-Wallis et al. 2017); **TG:** null association (**1/1 studies;** Hjorth et al. 2014a); **HDL cholesterol:** favourable association (**1/1 studies;** Hjorth et al. 2014a); 1/1 showed a null association with Blood Lipids (Telford et al. 2015) **HOMA:** associations were null (**1/1 studies;** Hjorth et al. 2014a), or mixed favourable (in boys but not girls at 4-yr follow-up) and null (2-yr follow-up) (Telford et al. 2009); 1/1 showed favourable association with IR (Peplies et al. 2016);	LOW[m]	

						Cardiometabolic disease risk score: null association (**1/1 studies;** Hjorth et al. 2014a). ***VPA:*** null associations with **systolic BP** (Carson et al. 2014). ***MVPA:*** **Systolic BP:** null association (**1/1 studies;** Knowles et al. 2013); **Diastolic BP:** null association (**1/1 studies;** Knowles et al. 2013); **Mean arterial BP:** null association (**1/1 studies;** Hjorth et al. 2014a); **TG:** null association (**2/2 studies;** Hjorth et al. 2014a, Chinapaw et al. 2018); **HDL cholesterol:** favourable association (**1/1 studies;** Hjorth et al. 2014a); TC:HDLC ratio and composite cardiometabolic risk 1/1 study showed favourable associations (Chinapaw et al. 2018) **HOMA:** null association (**3/3studies;** Hjorth et al. 2014a, Henderson et al. 2016, Chinapaw et al. 2018); **Cardiometabolic disease risk score:** null association (**1/1 studies;** Hjorth et al. 2014a). Liver fat & GGT: favourable association (1/1 Anderson et al. 2016) ***MPA:*** null associations with **systolic BP** (Carson et al. 2014). TG and HOMA-IR favourable association (1/1 Skrede et al.2017) ***LPA:*** null associations with **systolic BP** (Carson et al. 2014).		
47 Cross-sectional[n] N = 27,571	Serious risk of bias[o]	No serious inconsistency	No serious indirectness	No serious imprecision	Exposure/ outcome gradient[p]	Verswijveren et al. 2018 *(28)*: (4 cross-sectional studies; n=4,294): No included studies examined associations between patterns of LPA, MPA, or VPA and **blood lipids**. Two studies found no evidence of an association between MVPA and MPA and measures of **glucose** metabolism. No evidence of an association between PA bouts and **systolic BP, diastolic BP, large artery compliance, and small artery compliance** was found in 3 studies. Blood Pressure (Systolic BP, Diastolic BP, Mean Arterial BP): ***Meeting/Not Meeting Guidelines:*** **1 study** found that *meeting PA guidelines*[q] was associated with reduced odds of having **high BP**, but no difference in odds of **pre-high BP** or **risk of high** BP (de Moraes et al. 2015). **1 study** found that *meeting PA guidelines*[q] was associated with lower **systolic BP** and **diastolic BP** (Janssen et al. 2013). **1 study** found that *meeting 10,000 steps/day* did not impact the odds of having **high BP** (Schofield et al. 2009). ***Total PA:*** **Hypertension:** favourable dose-response gradient (**1/1 studies;** Mark and Janssen 2008). **Diastolic hypertension:** favourable association (**1/1 studies;** Knowles et al. 2013). **Systolic hypertension:** no association (**1/1 studies;** Knowles et al. 2013). **Systolic BP:** associations were favourable (**3/8 studies;** Andersen et al. 2006; Ekelund et al. 2006; Mark and Janssen 2008), null (**4/8 studies;** Leary et al. 2008; Owen et al.	VERY LOW[t]	

						2010; Knowles et al. 2013; Chaput et al. 2013), or mixed (favourable and null; **1/8 studies;** Hurtig-Wennlof et al. 2007). Mark and Janssen (2008) found a favourable dose-response gradient. **Diastolic BP:** associations were favourable (**6/8 studies;** Andersen et al. 2006; Ekelund et al. 2006; Mark and Janssen 2008; Owen et al. 2010; Knowles et al. 2013; Chaput et al. 2013), null (**1/8 studies;** Leary et al. 2008), or mixed (favourable and null; **1/8 studies;** Hurtig-Wennlof et al. 2007). Mark and Janssen (2008) found an inverse dose-response gradient. **Mean arterial BP:** null association (**1/1 studies;** Hjorth et al. 2014a). ***VPA:*** **High-normal systolic BP %:** was greatest in the lowest tertile of *VPA* (**1/1 studies;** Hay et al. 2012). **BP Z-score:** no association (**1/1 studies;** Stabelini Neto et al. 2014). ***MVPA:*** **Hypertension:** the likelihood of **hypertension** decreased in a curvilinear manner with *MVPA* (**1/1 studies;** Hjorth et al. 2014a). **BP Z-score:** favourable association (**1/1 studies;** Stabelini Neto et al. 2014). **Systolic BP:** associations were favourable (**4/9 studies;** Holman et al. 2011; Colley et al. 2012; Mendoza et al. 2012; Carson et al. 2013); null (**4/9 studies;** Leary et al. 2008; Hearst et al. 2012; Knowles et al. 2013; Chaput et al. 2013); or mixed (favourable and null; **1/9 studies;** Hurtig-Wennlof et al. 2007). **1 study** found a favourable association between *sporadic MVPA* and **systolic BP** (Holman et al. 2011). **Diastolic BP:** associations were favourable (**1/8 studies;** Chaput et al. 2013); null (**5/8 studies;** Leary et al. 2008; Colley et al. 2012; Mendoza et al. 2012; Hearst et al. 2012; Carson et al. 2013);or mixed (favourable and null; **2/8 studies;** Hurtig-Wennlof et al. 2007; Knowles et al. 2013). **Mean arterial BP:** null association (**1/1 studies;** Hjorth et al. 2014a). ***MPA:*** **BP Z-score:** favourable association (**1/1 studies;** Stabelini Neto et al. 2014). **Systolic BP:** null association (**1/1 studies;** Hay et al. 2012). ***LPA:*** **BP Z-score:** favourable association (**1/1 studies;** Stabelini Neto et al. 2014). **Systolic BP:** null associations (**2/2 studies;** Hay et al. 2012; Carson et al. 2013). **Diastolic BP:** favourable association (**1/1 studies;** Carson et al. 2013). <u>Triglycerides (TG):</u> ***Meeting/Not Meeting Guidelines:*** *meeting PA guidelines*[q] had a null association with fasting **TGs** (**1/1 studies;** Janssen et al. 2013). ***Total PA:*** associations were favourable (**3/7 studies;** Andersen et al. 2006; Ekelund et al. 2006; Owen et al. 2010), null (**2/7 studies;** Chaput et al. 2013; Hjorth et al.		

						2014a), or mixed (favourable and null; **2/7 studies;** Wennlof et al. 2005; Hurtig-Wennlof et al. 2007). ***VPA:*** null association (**1/1 studies;** Stabelini Neto et al. 2014). ***MVPA:*** associations were favourable (**1/7 studies;** LeBlanc and Janssen 2010) or null (**6/7 studies;** Hurtig-Wennlof et al. 2007; Mendoza et al. 2012; Carson et al. 2013; Chaput et al. 2013; Hjorth et al. 2014a; Stabelini Neto et al. 2014). ***MPA:*** null association (**1/1 studies;** Stabelini Neto et al. 2014). ***LPA:*** null associations (**2/2 studies;** Carson et al. 2013; Stabelini Neto et al. 2014). <u>Cholesterol:</u> ***Meeting/Not Meeting Guidelines:*** **HDL cholesterol:** *meeting PA guidelines*[q] was favourably associated with HDL (**1/1 studies;** Janssen et al. 2013). ***Total PA:*** **Total cholesterol:** associations were favourable (**1/2 studies;** Andersen et al. 2006), or mixed (favourable and null; **1/2 studies;** Hurtig-Wennlof et al. 2007). **HDL cholesterol:** associations were favourable (**2/5 studies;** Chaput et al. 2013; Hjorth et al. 2014a) or null (**3/5 studies;** Andersen et al. 2006; Hurtig-Wennlof et al. 2007; Owen et al. 2010). ***VPA:*** **HDL cholesterol:** null associations (**1/1 studies;** Stabelini Neto et al. 2014). ***MVPA:*** **"High risk" cholesterol:** increased *MVPA* was associated with reduced odds (**1/1 studies;** LeBlanc and Janssen 2010). **Total cholesterol:** associations were favourable (**1/3 studies;** Hurtig-Wennlof et al. 2007) or null (**2/3 studies;** Hurtig-Wennlof et al. 2007; Mendoza et al. 2012). **HDL cholesterol:** associations were favourable (**3/7 studies;** Mendoza et al. 2012; Chaput et al. 2013; Hjorth et al. 2014a) or null (**4/7 studies;** Hurtig-Wennlof et al. 2007; Hearst et al. 2012; Carson et al. 2013; Stabelini Neto et al. 2014). **Non-HDL cholesterol:** *MVPA* (total, bouts, sporadic) was favourably associated (**1/1 studies;** Holman et al. 2011). **LDL cholesterol:** null associations (**3/3 studies;** LeBlanc and Janssen 2010; Mendoza et al. 2012; Carson et al. 2013). ***MPA:*** **HDL cholesterol:** null associations (**1/1 studies;** Stabelini Neto et al. 2014). ***LPA:*** **HDL cholesterol:** associations were null (**1/2 studies;** Stabelini Neto et al. 2014) or mixed (favourable and null; **1/2 studies;** Carson et al. 2013). <u>Insulin Resistance:</u>		

						Meeting/Not Meeting Guidelines: **HOMA:** *meeting PA guidelines*[q] had no impact on **HOMA** (**1/1 studies;** Janssen et al. 2013). ***Total PA:*** **HOMA:** associations were favourable (**5/6 studies;** Andersen et al. 2006; Rizzo et al. 2008; Sardinha et al. 2008; Owen et al. 2010; Hjorth et al. 2014a), or null (**1/6 studies;** Jimenez-Pavon et al. 2013c). **QUICKI:** null association (**1/1 studies;** Jimenez-Pavon et al. 2013c). ***VPA:*** **HOMA:** associations were favourable (**1/2 studies;** Rizzo et al. 2008) or null (**1/2 studies;** Jimenez-Pavon et al. 2013c). **QUICKI:** null association (**1/1 studies;** Jimenez-Pavon et al. 2013c). ***MVPA:*** **HOMA:** associations were favourable (**4/7 studies;** Rizzo et al. 2008; Sardinha et al. 2008; Hjorth et al. 2014a; Henderson et al. 2014), null (**3/7 studies;** Henderson et al. 2012; Carson et al. 2013; Jimenez-Pavon et al. 2013c). **QUICKI:** null association (**1/1 studies;** Jimenez-Pavon et al. 2013c). **Matsuda score:** null association (**1/1 studies;** Henderson et al. 2012). **HOMA-%S:** favourable association (**1/1 studies;** Carson et al. 2013). **OGTT results (**AUC I/G_{t30min} or AUC I/$G_{t120min}$): null associations (**1/1 studies;** Henderson et al. 2014). ***MPA:*** **HOMA:** associations were favourable (**1/2 studies;** Rizzo et al. 2008), or null (**1/2 studies;** Jimenez-Pavon et al. 2013c). **QUICKI:** null association (**1/1 studies;** Jimenez-Pavon et al. 2013c). ***LPA:*** **HOMA:** associations were null (**4/4 studies;** Rizzo et al. 2008; Sardinha et al. 2008; Carson et al. 2013; Jimenez-Pavon et al. 2013c). **QUICKI:** null association (**1/1 studies;** Jimenez-Pavon et al. 2013c). **HOMA-%S:** null association (**1/1 studies;** Carson et al. 2013). <u>Fasting Insulin</u> ***Total PA:*** associations were favourable (**8/11 studies;** Brage et al. 2004a; Andersen et al. 2006; Ekelund et al. 2006; Butte et al. 2007b; Rizzo et al. 2008; Sardinha et al. 2008; Owen et al. 2010; Jimenez-Pavon et al. 2012), null (**1/11 studies;** Jimenez-Pavon et al. 2013c), or mixed (favourable and null) (**2/11 studies;** Wennlof et al. 2005; Hurtig-Wennlof et al. 2007).		

						VPA: associations were favourable (**2/4 studies;** Rizzo et al. 2008; Jimenez-Pavon et al. 2012), or null (**2/4 studies;** Butte et al. 2007b; Jimenez-Pavon et al. 2013c). ***MVPA:*** associations were favourable (**5/9 studies;** Rizzo et al. 2008; Sardinha et al. 2008; Henderson et al. 2012; Jimenez-Pavon et al. 2012; Carson et al. 2013), null (**2/9 studies;** Mendoza et al. 2012; Jimenez-Pavon et al. 2013c), or mixed (favourable and null **2/9 studies;** Hurtig-Wennlof et al. 2007; Butte et al. 2007b). Butte et al. 2007b found that *5-* but not *10-min bouts of MVPA* were favourably associated with fasting insulin. ***MPA:*** associations were favourable (**1/3 studies;** Butte et al. 2007b), null (**1/3 studies;** Jimenez-Pavon et al. 2013c), or mixed (favourable and null; **1/3 studies;** Rizzo et al. 2008). ***LPA:*** associations were favourable (**1/5 studies;** Butte et al. 2007b), or null (**4/5 studies;** Rizzo et al. 2008; Sardinha et al. 2008; Carson et al. 2013; Jimenez-Pavon et al. 2013c). <u>Fasting Glucose</u> ***Total PA:*** associations were favourable (**3/7 studies;** Andersen et al. 2006; Ekelund et al. 2006; Rizzo et al. 2008), null (**3/7 studies;** Brage et al. 2004a; Chaput et al. 2013; Jimenez-Pavon et al. 2013c), or mixed (favourable and null; **1/7 studies;** Hurtig-Wennlof et al. 2007). ***VPA:*** associations were favourable (**1/3 studies;** Rizzo et al. 2008), or null (**2/3 studies;** Jimenez-Pavon et al. 2013c; Stabelini Neto et al. 2014). ***MVPA:*** associations were favourable (**1/8 studies;** Rizzo et al. 2008), null (**6/8 studies;** Owen et al. 2010; Mendoza et al. 2012; Carson et al. 2013; Chaput et al. 2013; Jimenez-Pavon et al. 2013c; Stabelini Neto et al. 2014), or mixed (favourable and null) (**1/8 studies;** Hurtig-Wennlof et al. 2007). **1/1 studies** found no association between *MVPA* and **2-hr plasma glucose** (Carson et al. 2013). ***MPA:*** associations were favourable (**1/3 studies;** Rizzo et al. 2008), or null (**2/3 studies;** Jimenez-Pavon et al. 2013c; Stabelini Neto et al. 2014). ***LPA:*** associations were null (**4/4 studies;** Rizzo et al. 2008; Carson et al. 2013; Jimenez-Pavon et al. 2013c; Stabelini Neto et al. 2014). **1/1 studies** found no association with **2-hr plasma glucose** (Carson et al. 2013). <u>HbA1c</u> ***Total PA:*** null association (**1/1 studies;** Owen et al. 2010). ***MVPA:*** null association (**1/1 studies;** Mendoza et al. 2012). <u>Inflammatory Markers (CRP, TNF-α, IL-6, C3, C4)</u> ***Meeting/Not Meeting Guidelines:*** null association between *meeting PA guidelines*[r] and **CRP** (**1/1 studies;** Loprinzi et al. 2013). ***Total PA:*** **CRP:** null associations (**3/3 studies;** Owen et al. 2010; Martinez-Gomez et al. 2012; Loprinzi et al. 2013).		

						IL-6, TNF-α, C3 or **C4:** null associations (**1/1 studies;** Martinez-Gomez et al. 2012). ***VPA:*** **CRP**, **IL-6, TNF-α, C3** or **C4:** null associations (**1/1 studies;** Martinez-Gomez et al. 2012). ***MVPA:*** **CRP:** associations were favourable [increasing quartiles of *MVPA (total, bouts, sporadic)* were associated with reduced **CRP** (**1/5 studies;** Holman et al. 2011)], or null (**4/5 studies;** Mendoza et al. 2012; Martinez-Gomez et al. 2012; Carson et al. 2013; Loprinzi et al. 2013). *Bouts of MVPA* did not differ across CRP quartiles (**1/1 studies;** Loprinzi et al. 2013). **IL-6, TNF-α, C3** or **C4:** null associations (**1/1 studies;** Martinez-Gomez et al. 2012). ***MPA:*** **CRP**, **IL-6, TNF-α, C3** or **C4:** null associations (**1/1 studies;** Martinez-Gomez et al. 2012). ***LPA:*** **CRP:** null associations (**1/1 studies;** Carson et al. 2013). Alanine amino transferase: ***Total PA*** did not differ by **ALT** status, and % of awake time spent in ***VPA, MPA*** or ***LPA*** did not differ by **ALT** status (**1/1 studies;** Quiros-Tejeira et al. 2007). Artery properties: ***Total PA:*** negative association with **PWV** (**1/1 studies;** Sakuragi et al. 2009); null association with carotid **IMT** (**1/1 studies;** Lamotte et al. 2013). ***VPA:*** null associations with **IMT, carotid compliance, Young's elastic modules,** or **stiffness index** (**1/1 studies;** Ried-Larsen et al. 2013). ***MVPA:*** null associations with **IMT, carotid compliance, Young's elastic modules,** or **stiffness index** (**1/1 studies;** Ried-Larsen et al. 2013). Rate Pressure Product: ***Total PA, VPA,*** or ***MPA:*** null associations (**1/1 studies;** Mota et al. 2012). Cardiac sympathetic/parasympathetic modulation: ***MVPA:*** positively associated with one index of **cardiac parasympathetic modulation** (root mean square of successive differences) but not associated with another (high frequency power), and negatively associated with **sympathetic-parasympathetic balance** (**1/1 studies;** Gutin et al. 2005b). Homocysteine ***Total PA, MVPA, VPA*** or ***MPA:*** null associations (**1/1 studies;** Ruiz et al. 2007).		

						Composite Cardiometabolic Disease Risk Score ***Meeting/Not Meeting Guidelines:*** *meeting PA guidelines*[q,s] was associated with reduced **cardiometabolic risk score** (**2/2 studies;** Mendoza et al. 2012; Janssen et al. 2013); achieving 10,000 steps/day was not associated with different odds of having any number of **cardiovascular risk factors** (**1/1 studies;** Schofield et al. 2009). ***Total PA:*** associations were favourable (**3/7 studies;** Brage et al. 2004b; Ekelund et al. 2009; Jimenez-Pavon et al. 2013b), or null (**4/7 studies;** Rizzo et al. 2007; Schofield et al. 2009; Moreira et al. 2011; Hjorth et al. 2014a). **1/1 studies** found that *lower mean cadence values* were associated with larger accrued **numbers of risk factors** (Barreira et al. 2013). ***VPA:*** associations were favourable (**1/2 studies;** Jimenez-Pavon et al. 2013b), or null (**1/2 studies;** Stabelini Neto et al. 2014). ***MVPA:*** associations were favourable (**6/8 studies;** Ekelund et al. 2006; Nguyen et al. 2010; Holman et al. 2011; Carson and Janssen 2011; Jimenez-Pavon et al. 2013b; Stabelini Neto et al. 2014), null (**1/8 studies;** Hjorth et al. 2014a), or mixed (favourable and null; **1/8 studies;** Rey-Lopez et al. 2013). **1 study** found that the odds of a high cardiometabolic risk score decreased in a graded dose-response manner across quartiles of *sporadic MVPA* or *bout MVPA,* with similar associations for some individual cardiometabolic disease risk factors (non-HDL cholesterol, CRP, systolic BP) (Holman et al. 2011). ***MPA:*** favourable associations (**2/2 studies;** Jimenez-Pavon et al. 2013b; Stabelini Neto et al. 2014). ***LPA:*** null association (**1/1 studies;** Stabelini Neto et al. 2014)**.**		

Abbreviations: ALT = alanine amino transferase; AUC I/G_{t30min} and AUC $I/G_{t120min}$ = area under the curve of the ratio of insulin to glucose at 30 and 120 min post-oral glucose tolerance test; BP = blood pressure; C3 and C4 = complement factors 3 and 4; CRP = C-reactive protein; ES = effect size; HbA1c = glycosylated hemoglobin; HDL = high density lipoprotein cholesterol; HOMA = homeostatic model assessment insulin resistance; HOMA-%S = insulin sensitivity; IL-6 = interleukin-6; IMT = intima media thickness; LDL = low density lipoprotein cholesterol; LPA = light intensity physical activity; MPA = moderate intensity physical activity; MVPA = moderate-to-vigorous physical activity; OGTT = oral glucose tolerance test; PA = physical activity; PWV = pulse wave velocity; QUICKI = quantitative insulin sensitivity check index; RPP = rate-pressure product; sporadic MVPA = <5 consecutive minutes of moderate-to-vigorous physical activity; TG = triglycerides; TNF-α = tumor necrosis factor alpha; VPA = vigorous intensity physical activity.

[*]As determined by WHO

[a] Includes **2 studies** (Kriemler et al. 2010; Meyer et al. 2014) from one cluster randomized controlled trial (“Kinder-und Jugendsportstudie’’; KISS). Results are reported separately and participants are only counted once.

[b] Serious indirectness. Indirect comparisons: different durations and intensities of PA were not compared.

[c] MVPA (but not total PA) was significantly greater in the intervention vs control group at post-intervention (post 9-month intervention group difference of ~11 min/day) (Kriemler et al. 2010); there was a trend toward higher levels of total PA (but not MVPA) in the intervention vs control group at 3-yr follow-up (Cohen’s *d* = 0.35, p=0.06; not significant) (Meyer et al. 2014).

[d] The quality of the evidence from the randomized study was downgraded from “high” to “moderate” due to serious indirectness of the interventions and the comparisons being assessed.

[e] Includes **1 non-randomized intervention study** (Rowland et al. 1996).

[f] Serious risk of bias. PA outside of prescribed intervention was not controlled (e.g. sports teams/recreational programs) or measured, and it is unclear whether activity external to the intervention changed over the course of the study and/or may have influenced the results. Dietary analysis in a subset of non-randomly selected subjects (n=11) showed a decrease in caloric intake in the intervention vs control period (potentially important confounder) (Rowland et al. 1996).

[g] Serious indirectness. Indirect comparisons: different durations and intensities of physical activity were not compared.

[h] Training intensity estimated by HR monitor; mean HR during the training sessions was 174.4, SD = 10 bpm (Rowland et al. 1996).

[i] The quality of the evidence from the non-randomized study was downgraded from “low” to “very low” due to: (1) serious risk of bias in the included study that diminished the level of confidence in the observed effects, and (2) serious indirectness of comparisons.

[j] Includes **7 longitudinal studies** (Telford et al. 2009; Hallal et al. 2011; Telford et al. 2012a; Knowles et al. 2013; Hjorth et al. 2014a; Carson et al. 2014; de Moraes et al. 2015) from **6 unique samples**. **Two studies** reported data from the LOOK study (Telford et al. 2009; Telford et al. 2012a); results are reported separately and participants are only counted once.

[k] Serious risk of bias. Participants were divided into intervention (community-based healthy lifestyle promotion) and control (no treatment) groups, but possible group-effects were not considered and all analysis was reported pooled across groups (de Moraes et al. 2015). Sixty-eight percent of participants did not provide valid baseline accelerometer data or did not have complete cardiometabolic risk factor data at baseline and/or follow-up; reasons for missing data were not reported; those lost to follow-up were older, heaver and displayed lower cardiorespiratory fitness than those included at follow-up (Carson et al. 2014). Those included in analysis represent only ~10% of the total cohort (Hallal et al. 2011).

[l] Cut-point for "meeting" PA guidelines was ≥60 min MVPA/day (de Moraes et al. 2015).

[m] The quality of the evidence from longitudinal studies was not upgraded from "low" to "moderate" due to serious risk of bias in three studies that diminished the level of confidence in the observed effects.

[n] Includes **47 cross-sectional studies** (Brage et al. 2004a; Brage et al. 2004b; Wennlof et al. 2005; Gutin et al. 2005b; Andersen et al. 2006; Ekelund et al. 2006; Hurtig-Wennlof et al. 2007; Rizzo et al. 2007; Ruiz et al. 2007; Quiros-Tejeira et al. 2007; Butte et al. 2007b; Rizzo et al. 2008; Sardinha et al. 2008; Leary et al. 2008; Mark and Janssen 2008; Sakuragi et al. 2009; Ekelund et al. 2009; Schofield et al. 2009; Owen et al. 2010; LeBlanc and Janssen 2010; Nguyen et al. 2010; Holman et al. 2011; Carson and Janssen 2011; Moreira et al. 2011; Hay et al. 2012; Mota et al. 2012; Colley et al. 2012; Henderson et al. 2012; Mendoza et al. 2012; Jimenez-Pavon et al. 2012; Martinez-Gomez et al. 2012; Hearst et al. 2012; Barreira et al. 2013; Rey-Lopez et al. 2013; Carson et al. 2013; Janssen et al. 2013; Lamotte et al. 2013; Knowles et al. 2013; Chaput et al. 2013; Ried-Larsen et al. 2013; Loprinzi et al. 2013; Jimenez-Pavon et al. 2013b; Jimenez-Pavon et al. 2013c; Hjorth et al. 2014a; Stabelini Neto et al. 2014; Henderson et al. 2014; de Moraes et al. 2015) from **20 unique samples**. **Two studies** reported data from the CHMS (Colley et al. 2012; Janssen et al. 2013); **12 studies** reported data from the EYHS (Brage et al. 2004a; Brage et al. 2004b; Wennlof et al. 2005; Andersen et al. 2006; Ekelund et al. 2006; Hurtig-Wennlof et al. 2007; Rizzo et al. 2007; Ruiz et al. 2007; Rizzo et al. 2008; Sardinha et al. 2008; Ekelund et al. 2009; Ried-Larsen et al. 2013); **5 studies** reported data from HELENA (Jimenez-Pavon et al. 2012; Martinez-Gomez et al. 2012; Rey-Lopez et al. 2013; Lamotte et al. 2013; Jimenez-Pavon et al. 2013c); **2 studies** reported data from IDEFICS (Jimenez-Pavon et al. 2013b; de Moraes et al. 2015); **8 studies** reported data from NHANES (Mark and Janssen 2008; LeBlanc and Janssen 2010; Holman et al. 2011; Carson and Janssen 2011; Mendoza et al. 2012; Barreira et al. 2013; Carson et al. 2013; Loprinzi et al. 2013); **3 studies** reported data from QUALITY (Henderson et al. 2012; Chaput et al. 2013; Henderson et al. 2014); **2 studies** reported data from Viva la Familia (Quiros-Tejeira et al. 2007; Butte et al. 2007b); results are reported separately and participants are only counted once.

[o] Serious risk of bias. Participants were divided into intervention (community-based healthy lifestyle promotion) and control (no treatment) groups, but possible group-effects were not considered and all analysis was reported pooled across groups (de Moraes et al. 2015). Many studies had a large amount of missing data, or did not report sufficient information to determine the proportion of missing data (Gutin et al. 2005b; Andersen et al. 2006; Hurtig-Wennlof et al. 2007; Rizzo et al. 2007; Rizzo et al. 2008; Mark and Janssen 2008; Ekelund et al. 2009; LeBlanc and Janssen 2010; Holman et al. 2011; Carson and Janssen 2011; Mota et al. 2012; Mendoza et al. 2012; Carson et al. 2013; Janssen et al. 2013; Ried-Larsen et al. 2013; Jimenez-Pavon et al. 2013b; Stabelini Neto et al. 2014). Possible detection bias as participants were retained if they provided PA data for at least 1-7 days; 68% provided at least 5 days of PA data and at 32% provided 1-4 days; PA levels were slightly higher in those with fewer days of PA data; MVPA and LPA were recorded but not reported (Owen et al. 2010). Participants with missing data differed from those included in the analysis on some outcome measures (Andersen et al. 2006; Jimenez-Pavon et al. 2013c). Potential failure to adjust for relevant confounders (Barreira et al. 2013). No information provided regarding criteria for valid exposure measurement; possible detection bias (Quiros-Tejeira et al. 2007). Possible selective reporting bias (systolic BP reported in absence of diastolic BP); not possible to discern which potentially important confounders were included in the analyses (Hay et al. 2012). Possible detection bias; participants were excluded from the study if they did not wear the pedometer for >4 hours in total over the full 4 days of data collection (Schofield et al. 2009).

[p] Exposure/outcome gradients were observed in **4 studies** (Andersen et al. 2006; Mark and Janssen 2008; Holman et al. 2011; Hay et al. 2012) from **3 unique samples**.

[q] Cut-point for "meeting" PA guidelines was ≥ 60 min MVPA/day (Janssen et al. 2013; de Moraes et al. 2015).

[r] Cut-point for "meeting" PA guidelines was ≥ 60 min of at least moderate intensity PA, daily (1 min bouts) (Loprinzi et al. 2013).

[s] Cut-point for "meeting" PA guidelines was ≥ 60 min MVPA/day on 5 of 7 days (Mendoza et al. 2012).

[t] The quality of evidence from cross-sectional studies was downgraded from "low" to "very low" due to serious risk of bias in 24 studies that diminished the level of confidence in the observed effects.

Table A.1.c. Bone health and physical activity, children and adolescents

Questions: What is the association between **physical activity** and health-related outcomes? Is there a dose response association (volume, duration, frequency, intensity)? Does the association vary by type or domain of PA?
Population: Children aged 5-under 18 years of age
Exposure: Greater volume, duration, frequency, or intensity of physical activity
Comparison: No physical activity or lesser volume, duration, frequency, or intensity of physical activity
Outcome: Bone health
*__Importance__: CRITICAL

Black font is from original GRADE Evidence Profiles from Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (12-17 years).*(6)* Red font denotes additions based on WHO update using review of existing systematic reviews.

	Quality Assessment							
No. of studies/ Study design No. of participants	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other**	**Summary of findings**	**Certainty**	**US PAGAC evidence and conclusions *(30)***
The range of mean ages was 5.2 to 17.7 years. Data were collected by RCT, cross-sectionally, and up to 12 years of follow-up. Measures included: BMD, BMC, scanned area, cross-sectional area, total skeletal area, section modulus, bone stress index, femur and tibia bone strength index, strength-strain index, polar moment of inertia, cross-sectional moment of inertia, periosteal and endosteal circumference, cortical thickness, cortical BMC, cortical bone area, BMD ratios (femoral neck to trochanter, femoral neck to intertrochanter, trochanter to intertrochanter). All outcomes were measured objectively by DXA or peripheral quantitative CT.								
2 RCTs[a] N = 73 **No eligible reviews identified.**	No serious risk of bias	No serious inconsistency	Serious indirectness[b]	No serious imprecision	None	In both groups, **BMD** increased more during periods of physical training than during periods of no physical training (Gutin et al. 1999).	MODERATE[c]	10 ESRs Strong evidence demonstrates that children and youth who are more physically active than their peers have higher bone mass, improved bone structure, and greater bone strength. **PAGAC Grade: Strong**.
7 Longitudinal[d] N = 948 **No eligible reviews identified.**	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	*Total PA* **1 study** reported that baseline *total PA* predicted follow-up **BMC** at the **hip, trochanter, spine** and **whole body** in *boys* and at the **trochanter** and **whole body** in *girls* (data not shown). **Total PA** explained 1-2% of the variability in **BMC** (Janz et al. 2006). Children who maintained **high levels of PA** over the 3-yr period (≥50th percentile) accrued, on average, 14% more **trochanteric BMC** and 5% more **whole-body BMC** relative to peers maintaining **low levels of PA** (<50th percentile) (Janz et al. 2006). **1 study** found that spending a higher proportion of total PA in MPA-VPA relative to LPA was favourably associated with **BMC, BMD** and **bone area** (Heidemann et al. 2013). *VPA*	MODERATE[e]	

						Hip and **spine BMC:** mixed (favourable and null) associations (**2/2 studies;** Janz et al. 2014a; Francis et al. 2014). *MVPA* **Whole body, spine** and **hip BMC:** mixed (favourable and null) associations (**3/3 studies;** Janz et al. 2010; Francis et al. 2014; Janz et al. 2014b); **Hip BMD:** mixed (favourable and null) associations (**1/1 studies;** Janz et al. 2014b). **Femoral neck cross-sectional area** and **section modulus:** mixed (favourable and null) associations (**2/2 studies;** Janz et al. 2007; Janz et al. 2014b); **Measures of bone strength** (**bone stress index** and **polar moment of inertia**): mixed (favourable and null) associations (**1/1 studies;** Janz et al. 2014b).		
14 Cross-sectional[f] N = 6,520 **No eligible reviews identified.**	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	*Meeting/Not Meeting Guidelines (≥60 min/day MVPA)* **1 study** reported that meeting guidelines had no association with **BMC** (whole body, hip, lumbar spine, trochanter, intertrochanter, femoral) (Gracia-Marco et al. 2011a). **1 study** reported that meeting guidelines had mixed favourable, null, and unfavourable associations with **BMC** of at least 1 anatomical region (**whole body, upper limb, lower limb)** (Gracia-Marco et al. 2011b). **1 study** reported that meeting guidelines had mixed favourable (girls) and null (boys) associations (**lumbar spine**) or null associations (**whole body, hip, trochanter, intertrochanter** or **femoral neck**) with **BMD** (Gracia-Marco et al. 2011a). *Total PA* *Total PA and BMC:* **Whole body BMC:** associations were favourable (**1/2 studies;** Gracia-Marco et al. 2012), or mixed (favourable in boys, null in girls; **1/2 studies**; Janz et al. 2001); **Hip BMC:** favourable associations (**2/2 studies;** Janz et al. 2001; Gracia-Marco et al. 2012); **Spine BMC:** favourable association (**1/1 studies;** Janz et al. 2001). *Total PA and BMD:* **Whole body BMD:** null associations (**1/1 studies;** Janz et al. 2001); **Hip BMD:** favourable associations (**1/1 studies;** Janz et al. 2001); **Spine BMD:** mixed (null in boys, favourable in girls) associations (**1/1 studies;** Janz et al. 2001); **Calcaneal** and **distal forearm BMD:** favourable associations (**1/1 studies;** Hasselstrom et al. 2007). *Total PA and Area and strength:* **Total skeletal area:** favourable associations (**1/1 studies;** Janz et al. 2001). **Femur** and **tibia strength index/strength-strain index:** mixed (favourable and null) associations (**1/1 studies;** Farr et al. 2011). *VPA* *VPA and BMC:* **Whole body BMC:** associations were favourable (**1/1 studies;** Tobias et al. 2007) or mixed (favourable in boys, null in girls; **1/1 studies;** Janz et al. 2001);	LOW[g]	

						Whole body BMC adjusted for bone area: null associations (**1/1 studies;** Tobias et al. 2007); **Hip BMC:** favourable associations (**2/2 studies;** Janz et al. 2001 and 2014a); **Spine BMC:** associations were favourable (**2/3 studies;** Janz et al. 2001 and 2014a) or null (**1/3 studies;** Francis et al. 2014). **Upper limb *absolute* BMC:** favourable associations (**1/1 studies;** Tobias et al. 2007); **Lower limb *absolute* BMC:** null associations (**1/1 studies;** Tobias et al. 2007); **Upper** and **lower limb *areal* BMC:** null associations (**1/1 studies;** Tobias et al. 2007); **Cortical BMC:** favourable associations (**1/1 studies**; Sayers et al. 2011). *VPA and BMD:* **Whole body BMD:** associations were favourable (**1/2 studies;** Tobias et al. 2007) or null (**1/2 studies**; Janz et al. 2001); **Whole body *areal* BMD:** favourable associations (**1/1 studies;** Tobias et al. 2007); **Hip BMD:** favourable associations (**1/1 studies;** Janz et al. 2001); **Spine BMD:** mixed (null in boys, favourable in girls) associations (**1/1 studies;** Janz et al. 2001); **Calcaneal** and **distal forearm:** favourable associations (**1/1 studies;** Hasselstrom et al. 2007); **Upper limb *absolute*** or ***areal* BMD:** favourable associations (**1/1 studies;** Tobias et al. 2007); **Lower limb *absolute*** or ***areal* BMD:** null associations (**1/1 studies;** Tobias et al. 2007); **Femoral neck, trochanter** and **intertrochanter BMD:** favourable associations (**1/1 studies;** Cardadeiro et al. 2012); **Cortical BMD:** unfavourable associations (**1/1 studies;** Sayers et al. 2011); **BMD ratios:** null (femoral neck to intertrochanter, trochanter to intertrochanter) or mixed (null in boys, negative in girls; femoral neck to intertrochanter) associations (**1/1 studies;** Cardadeiro et al. 2012). *VPA and Area and strength:* **Total skeletal area:** favourable association (**1/1 studies;** Janz et al. 2001); **Cortical bone area:** favourable association (**1/1 studies;** Sayers et al. 2011); **Periosteal circumference of the tibia:** positive association (**1/1 studies;** Sayers et al. 2011); **Endosteal circumference of the tibia:** negative association (**1/1 studies;** Sayers et al. 2011); **Cross-sectional area** and **section modulus** of **narrow neck, intertrochantic** and **shaft** regions of **femur:** favourable associations (**1/1 studies;** Janz et al. 2004). <u>MVPA</u> *MVPA and BMC:* **Whole body BMC:** mixed (favourable and null) associations (**1/1 studies;** Janz et al. 2008); **Hip BMC:** favourable associations (**2/2 studies;** Janz et al. 2008; Janz et al. 2014a); **Spine BMC:** mixed (favourable in boys, null in girls) associations (**2/3 studies;** Janz et al. 2008; Janz et al. 2014a), or null associations (**1/3 study;** Francis et al. 2014).		

						MVPA and BMD: **Femoral neck, trochanter** and **intertrochanter BMD:** null associations (**1/1 studies;** Cardadeiro et al. 2012); **BMD ratios:** null (femoral neck to trochanter, trochanter to intertrochanter) or mixed (null in boys, positive in girls; femoral neck to intertrochanter) associations (**1/1 studies;** Cardadeiro et al. 2012). *MPA* *MPA and BMC:* **Whole body *absolute* or *areal* BMC:** favourable associations (**1 /1 studies;** Tobias et al. 2007); **Upper limb *absolute* or *areal* BMC:** null associations (**1/1 studies;** Tobias et al. 2007); **Lower limb *absolute* or *areal* BMC:** favourable associations (**1/1 studies;** Tobias et al. 2007); **Cortical BMC:** null associations (**1/1 studies**; Sayers et al. 2011). *MPA and BMD:* **Whole body *absolute* or *areal* BMD:** favourable associations (**1/1 studies;** Tobias et al. 2007); **Upper limb *absolute* or *areal* BMD:** null associations (**1/1 studies;** Tobias et al. 2007); **Lower limb *absolute* or *areal* BMD:** favourable associations (**1/1 studies;** Tobias et al. 2007); **Femoral neck, trochanter, intertrochanter BMD:** null associations (**1/1 studies;** Cardadeiro et al. 2012); **Cortical BMD:** null associations (**1/1 studies;** Sayers et al. 2011); **BMD ratios:** null (femoral neck to trochanter, femoral neck to intertrochanter, trochanter to intertrochanter; **1/1 studies;** Cardadeiro et al. 2012). *MPA and Area and strength:* **Cortical bone area:** favourable association (**1/1 studies;** Sayers et al. 2011); **Periosteal** and **endosteal circumference of the tibia:** null associations (**1/1 studies;** Sayers et al. 2011); **Cross-sectional area** of **femoral shaft:** favourable associations (**1/1 studies;** Janz et al. 2004); **Section modulus** of **femoral shaft:** mixed (null in boys, favourable in girls) associations (**1/1 studies;** Janz et al. 2004); **Cross-sectional area** and **section modulus** of **narrow neck** and **intertrochantic** regions of **femur:** mixed (null in boys, favourable in girls) associations (**1/1 studies;** Janz et al. 2004). *LPA* *LPA and BMC:* **Whole body *absolute* or *areal* BMC:** null associations (**1/1 studies**; Tobias et al. 2007); **Upper** or **lower limb *absolute* BMC:** favourable associations (**1/1 studies;** Tobias et al. 2007);		

						Upper or **lower limb *areal* BMC:** null associations (**1/1 studies;** Tobias et al. 2007); **Cortical BMC:** null associations (**1/1 studies**; Sayers et al. 2011)**.** *LPA and BMD:* **Whole body BMD:** favourable associations (**1/1 studies;** Tobias et al. 2007); **Whole body *areal* BMD:** null associations (**1/1 studies;** Tobias et al. 2007); **Upper** and **lower limb *absolute* or *areal* BMD:** favourable associations (**1/1 studies;** Tobias et al. 2007); **Cortical BMD:** unfavourable association (**1/1 studies;** Sayers et al. 2011). *LPA and Area and strength:* **Cortical bone area:** null association (**1/1 studies**; Sayers et al. 2011); **Periosteal circumference of the tibia:** positive association (**1/1 studies;** Sayers et al. 2011); **Endosteal circumference of the tibia:** null association (**1/1 studies;** Sayers et al. 2011). *Other (impact measured by g-band)* **1/1 studies** (Deere et al. 2012) found both favourable (higher impacts) and null (lower impacts) associations between impact and **BMD** (femoral neck, hip), **hip structure** (femoral neck width, cross-sectional area, cortical thickness) and **predicted strength** (cross-sectional moment of inertia). A dose-response gradient was found for higher impact activity and **BMD** (femoral neck, total hip).		

Abbreviations: BMC = bone mineral content; BMD = bone mineral density; CSA = cross sectional area; CT = computer tomography; DXA = dual-energy x-ray absorptiometry; LPA = light intensity physical activity; MPA = moderate physical activity; MVPA = moderate-and-vigorous physical activity; PA = physical activity; VPA = vigorous physical activity.

[*] As determined by WHO

[a] Includes **1 randomized-controlled trial** (Gutin et al. 1999).

[b] Serious indirectness. Differences in intervention: the RCT examined a training program that provided indirect evidence bearing on the potential effectiveness of different intensities and durations of PA. Indirect comparisons: different durations and intensities of PA were not compared.

[c] The quality of the evidence from the randomized study was downgraded from "high" to "moderate" due to serious indirectness of the intervention being assessed.

[d] Includes **7 longitudinal studies** (Janz et al. 2006; Janz et al. 2007; Janz et al. 2010; Heidemann et al. 2013; Francis et al. 2014; Janz et al. 2014a; Janz et al. 2014b) from **2 unique samples**. **Six studies** reported data from the Iowa Bone Development Study (Janz et al. 2006; Janz et al. 2007; Janz et al. 2010; Francis et al. 2014; Janz et al. 2014a; Janz et al. 2014b) and **1 study** reported data from the CHAMPS study sample (Heidemann et al. 2013). Results are reported separately and participants are only counted once.

[e] The quality of evidence from longitudinal studies was upgraded from "low" to "moderate" due to no serious risk of bias.

[f] Includes **14 cross-sectional studies** (Janz et al. 2001; Janz et al. 2004; Hasselstrom et al. 2007; Tobias et al. 2007; Janz et al. 2008; Sayers et al. 2011; Farr et al. 2011; Gracia-Marco et al. 2011a; Gracia-Marco et al. 2011b; Cardadeiro et al. 2012; Gracia-Marco et al. 2012; Deere et al. 2012; Francis et al. 2014; Janz et al. 2014a), from **6 unique samples**. **Five** studies reported data from the Iowa Bone Development Study (Janz et al. 2001; Janz et al. 2004; Janz et al. 2008; Francis et al. 2014; Janz et al. 2014a), **3 studies** from the ALSPAC (Tobias et al. 2007; Sayers et al. 2011; Deere et al. 2012), **3 studies** from HELENA (Gracia-Marco et al. 2011a; Gracia-Marco et al. 2011b; Gracia-Marco et al. 2012), and **1 study** from each of CoSCIS (Hasselstrom et al. 2007), EYHS (Cardadeiro et al. 2012), and Jump-In: Building Better Bones (Farr et al. 2011). Results are reported separately and participants are only counted once.

[g] The quality of the evidence from cross-sectional studies remained rated as "low" as there were no serious limitations across studies or reasons to upgrade.

Table A.1.d. Adiposity/body composition and physical activity, children and adolescents

Questions: What is the association between **physical activity** and health-related outcomes? Is there a dose response association (volume, duration, frequency, intensity)? Does the association vary by type or domain of PA?
Population: Children aged 5-under 18 years of age
Exposure: Greater volume, duration, frequency, or intensity of physical activity
Comparison: No physical activity or lesser volume, duration, frequency, or intensity of physical activity
Outcome: Adiposity/Body composition
***Importance**: CRITICAL

Black font is from original GRADE Evidence Profiles from Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (12-17 years).*(6)* Red font denotes additions based on WHO update using review of existing systematic reviews.

	Quality Assessment							
No. of studies/ Study design **No. of participants**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other**	**Summary of findings**[a]	**Certainty**	**US PAGAC evidence and conclusions** ***(30)***
The range of mean ages was 6.9 to 12 years. Data were collected by RCT, non-randomized intervention trial, cross-sectionally and up to 3 years of follow-up. Body composition markers were: BMI (absolute, percentile, Z-score, conditional Z-score velocity), weight status (CDC, IOTF or WHO cut-points), sum of SF, body mass, WC, %BF, FM, FM index, FFM, FFM index, ponderal index, and trunk fat. Outcomes were measured objectively in all but one instance.								
9 RCTs[b] n=3,957	Serious risk of bias[c]	No serious inconsistency	Serious indirectness[d]	No serious imprecision Serious imprecision	New systematic reviews were limited to specific physical activity interventi ons (laborator y-based HIIT, classroom -based active learning, resistance training)	Collins et al. 2018 *(12)* (18 RCTs; n=1,153): Significant, small effect sizes were identified comparing resistance training interventions vs. no resistance training for %BF (Hedges' g = 0.215 [95% CI, 0.059 to 0.371], p = 0.007) and SF thickness (Hedges' g = 0.274 [95% CI, 0.066 to 0.483, p = 0.01) but were not significant for BMI, FFM, FM, lean mass, or WC. Eddolls et al. 2017 *(13)* (13 RCTs; n=1,899): No consistent evidence of an effect of HIIT vs. moderate-intensity PA on changes in body composition as measured by BMI, %BF, or FFM, although most trials found a general trend of greater changes in body composition in high- vs. moderate-intensity groups. Martin et al. 2017 *(21)*: (2 RCTs, 1 NRT; n=6,980): All 3 studies reported small effect sizes with **2/3 studies** reporting no difference in BMI between classroom-based physical activity interventions vs. no intervention. **2/9 studies** reported improved adiposity for intervention vs control at post-test (Gutin et al. 1999; Eather et al. 2013); **4/9 studies** reported mixed favourable and null findings (Verstraete et al. 2007; Kriemler et al. 2010; Ford et al. 2013, Harrington et al 2018). **2/9 studies** had no intervention effects (Finkelstein et al. 2013, Drummy et al. 2016); **1/9 studies** reported that significant favourable effects in Kriemler et al.	LOW[f]	10 ESRs Strong evidence demonstrates that higher levels of physical activity are associated with smaller increases in weight and adiposity during childhood and adolescence. **PAGAC Grade: Strong**

						2010 were null at 3 year follow up (Meyer et al. 2014). Favourable effects for %BF, but not FM, remained at 15-week follow up for Ford et al. 2013.[e]		
11 NRT[g] n=4,552 **No reviews limited to NRTs identified.**	Serious risk of bias[h]	No serious inconsistency	Serious of indirectness[i]	No serious imprecision	NR	**6/11 studies** reported null effects of PA intervention on adiposity outcomes (Rowland et al. 1996; Pangrazi et al. 2003; Williams and Warrington 2011; Huang et al. 2012; Duncan et al. 2012, Aires et al. 2015). **4/11 studies** reported significant effects of PA intervention on adiposity outcomes (Benjamin Neelon et al. 2015, Postler et al. 2017, Brusseau et al. 2016) **1/11 studies** reported lower odds of overweight/obesity halfway through (1 year) a school/afterschool-based **total PA** intervention program, at post-test (2 years) and at 2-year follow-up (Sigmundova and Sigmund 2012).	VERY LOW[j]	
19 Longitudinal[k] n=28,141	Serious risk of bias[l]	No serious inconsistency	No serious indirectness	No serious imprecision	NR	Miguel-Berges et al. 2018 *(22)*: (6 longitudinal studies; n=1,834): All studies found a negative relationship between pedometer-measured PA and measures of BMI or WC, with only 2 of 6 studies reporting these associations to be statistically significant. ***Total PA:*** **1/8 studies** reported favourable associations (Janz et al. 2005); **3/8 studies** reported mixed favourable and null associations (Riddoch et al. 2009; White and Jago 2012, Griffiths et al. 2016); **4/8 studies** reported null associations (Butte et al. 2007a; Basterfield et al. 2012; Hjorth et al. 2014a; Hjorth et al. 2014b). ***VPA:*** **3/4 studies** reported favourable associations (total and bouts, Janz et al. 2005; dose-response trend, Carson et al. 2014, Hamer et al 2018); **1/4 studies** reported null associations (Butte et al. 2007a). ***MVPA:*** **5/10 studies** reported favourable associations (Janz et al. 2009; Mitchell et al. 2013, Augustin et al 2017,Chinapaw et al. 2018, Henderson et al. 2016); **2/10 studies** reported mixed favourable and null associations (Riddoch et al. 2009; Hjorth et al. 2014b); **3/10 studies** reported null associations (Stevens et al. 2007; Hallal et al. 2012; Hjorth et al. 2014a). ***MPA:*** **2/2 studies** reported null associations (total and bouts, Janz et al. 2005; Butte et al. 2007a). ***LPA:*** **2/3 studies** reported null associations (Butte et al. 2007a; Treuth et al. 2009); **1/3 studies** reported an unfavourable association, with evidence of dose-response gradient (Carson et al. 2014). <u>**FFM**</u> ***Total PA:*** **1/1 studies** reported mixed favourable and null associations (Stevens et al. 2004).	LOW[m]	

48 Cross-sectional[n] n=57,696	Serious risk of bias[o]	Serious inconsistency[p]	No serious indirectness	No serious imprecision	NR	Miguel-Berges et al. 2018 *(22)*: (30 cross-sectional studies; n=19,006): Most studies (24/30) found a statistically significant association between higher levels of pedometer-measured PA and lower adiposity, as measured by BMI and WC. Mohammadi et al. 2019 *(23)*: (10 cross-sectional studies; n=NR): **4/7 studies** found significant associations between **total** PA and weight status, BMI, %BF, and WC among Malaysian adolescents whereas 3**/7 studies** found null results. ***Meeting/Not Meeting Guidelines (≥60 min/day MVPA):*** **2/3 studies** reported favourable associations (Steele et al. 2009; Martinez-Gomez et al. 2010b); **1/3 studies** reported null associations (Mendoza et al. 2012). ***Total PA:*** **9/22 studies** reported favourable associations (Duncan et al. 2008; Riddoch et al. 2009; Steele et al. 2009; Ferrar and Olds 2010; Owen et al. 2010; Belcher et al. 2010; Mark and Janssen 2011; Ekstedt et al. 2013; Manios et al. 2013). **8/22 studies** reported mixed favourable and null associations (Andersen et al. 2006; Duncan et al. 2006; Ness et al. 2007; Ortega et al. 2007; Dollman et al. 2010; Ruiz et al. 2011; Tudor-Locke et al. 2011; Jimenez-Pavon et al. 2013c). **3/22 studies** reported null associations (Ekelund et al. 2006; Hands et al. 2009; Martinez-Gomez et al. 2012). **1/22 studies** reported mixed favourable, null, and unfavourable associations (Jimenez-Pavon et al. 2013a). **1/22 studies** reported mixed null and unfavourable associations (Hands and Parker 2008). ***VPA:*** **10/15 studies** reported favourable associations (Ekelund et al. 2004; Lohman et al. 2006; Steele et al. 2009; Martinez-Gomez et al. 2010b; Mark and Janssen 2011; Sayers et al. 2011; Chung et al. 2012; Martinez-Gomez et al. 2012; Jimenez-Pavon et al. 2013a; Katzmarzyk et al. 2015b). **4/15 studies** reported mixed favourable and null associations (Ortega et al. 2007; Kelly et al. 2010; Belcher et al. 2010; Jimenez-Pavon et al. 2013c). **1/15 studies** reported mixed null and unfavourable associations (Ortega et al. 2010). ***MVPA:*** **20/30 studies** reported favourable associations (Ekelund et al. 2004; Lohman et al. 2006; Ness et al. 2007; Stevens et al. 2007; Mark and Janssen 2009; Riddoch et al. 2009; Steele et al. 2009; Belcher et al. 2010; Martinez-Gomez et al. 2010b; Holman et al. 2011; Grydeland et al. 2012; Lawman et al. 2012; Carson et al. 2013; Ekstedt et al. 2013; Jimenez-Pavon et al. 2013a; Taverno Ross et al. 2013; daSilva et al. 2014; Young et al. 2014; Katzmarzyk et al. 2015a; Katzmarzyk et al. 2015b).	VERY LOW[q]	

						6/30 studies reported mixed favourable and null associations (Kelly et al. 2010; Peart et al. 2011; Ruiz et al. 2011; Mendoza et al. 2012; St George et al. 2013; Jimenez-Pavon et al. 2013c). **3/30 studies** reported null associations (Hurtig-Wennlof et al. 2007; Ortega et al. 2007; Martinez-Gomez et al. 2012). **1/30 studies** reported mixed null and unfavourable associations (Ortega et al. 2010). **2 studies** examined *sporadic MVPA* (i.e. 1-4 min bouts) and associations were favourable (Mark and Janssen 2009; Holman et al. 2011). **3 studies** examined *bouts of MVPA* and associations were favourable (**2/3 studies;** Holman et al. 2011; da Silva et al. 2014) or mixed (favourable and null; **1/3 studies;** Mark and Janssen 2009). ***MPA:*** **2/10 studies** reported favourable associations (Mark and Janssen 2011; Chung et al. 2012). **2/10 studies** reported mixed favourable and null associations (Belcher et al. 2010; Jimenez-Pavon et al. 2013c). **5/10 studies** reported null associations (Ortega et al. 2007; Steele et al. 2009; Sayers et al. 2011; Martinez-Gomez et al. 2012; Jimenez-Pavon et al. 2013a). **1/10 studies** reported mixed null and unfavourable associations (Ortega et al. 2010). **No studies** reported only unfavourable associations. ***LPA :*** **1/9 studies** reported favourable associations (Mark and Janssen 2011). **2/9 studies** reported mixed favourable and null associations (Treuth et al. 2009; Kwon et al. 2011). **3/9 studies** reported null associations (Ekelund et al. 2004; Sayers et al. 2011; Carson et al. 2013). **3/9 studies** reported mixed null and unfavourable associations (Steele et al. 2009; Jimenez-Pavon et al. 2013a; Jimenez-Pavon et al. 2013c). **<u>FFM</u>** **Total PA:** **1/2 studies** reported favourable associations (Ness et al. 2007); **1/2 studies** reported mixed favourable and null associations (Jimenez-Pavon et al. 2013a). **VPA :** **2/4 studies** reported favourable associations (Jimenez-Pavon et al. 2013a; Sayers et al. 2011); **2/4 studies** reported mixed null and unfavourable associations (Lohman et al. 2006; Lohman et al. 2008). **MVPA:**		

						1/4 studies reported null associations (Jimenez-Pavon et al. 2013a); **3/4 studies** reported mixed null and unfavourable associations (Lohman et al. 2006; Lohman et al. 2008; Taverno Ross et al. 2013). **MPA:** **2/2 studies** reported null associations (Jimenez-Pavon et al. 2013a; Sayers et al. 2011). **LPA:** **1/2 studies** reported favourable associations (Sayers et al. 2011); **1/2 studies** reported mixed unfavourable (boys) and null (girls) associations (Jimenez-Pavon et al. 2013a).		

Abbreviations: %BF = percent body fat; BMI = body mass index; CTRL = control group; FFM = fat free mass; FM = fat mass; HITT = high-intensity interval training; INT = intervention group; LPA = light physical activity; MPA = moderate physical activity; MVPA = moderate-to-vigorous physical activity; NR = not reported; RCT = randomized controlled trial; SF = skinfold; WC = waist circumference.

[*]As determined by WHO

[a] Summary of findings are absolute effects in relation to adiposity-specific indicators unless otherwise stated (i.e. in relation to FFM).

[b] Includes **6 RCT studies** (Verstraete et al. 2007; Kriemler et al. 2010; Finkelstein et al. 2013; Eather et al. 2013; Ford et al. 2013; Meyer et al. 2014) from **5** unique samples, and **1 modified randomized crossover study** (Gutin et al. 1999). Kriemler et al. 2010 and Meyer et al. 2014 both report data from the KISS study. Results are reported separately, and participants are only counted once.

[c] Serious risk of bias. Performance bias: Randomization was reported, but the method by which sibling pairs were further randomized beyond the initial randomization was not described and it is plausible that siblings discussed and detected group assignment (Finkelstein et al. 2013). Detection bias: 6 min walk test assessors were not blinded to group assignment; pedometers were open for INT, but sealed for CTRL, which could have influenced the outcome; missing pedometer data were disproportionately high in controls relative to intervention group (18.1% vs 6.1%), likely due to incentives for wear time offered to the intervention group only (Finkelstein et al. 2013). Selective reporting: %BF from BodPod was not available at follow up and reasons were not described. Many analyses were only reported for sub-samples with no explanation. Sequence generation: unclear how the subsample of children who had objective PA measures was selected (Ford et al. 2013).

[d] Serious indirectness. Differences in intervention: studies examined various types of physical activity programs and provided indirect evidence bearing on the potential effectiveness of different intensities and durations of physical activity. Indirect comparisons: different durations and intensities of physical activity were not compared within individual studies.

[e] MVPA (but not total PA) was significantly greater in the intervention vs control group at post-intervention (post 9-month intervention group difference of ~11 min/day) (Kriemler et al. 2010); there was a trend toward higher levels of total PA (but not MVPA) in the intervention vs control group at 3-yr follow-up (Cohen's *d* = 0.35, p=0.06; not significant) (Meyer et al. 2014).

[f] The quality of the evidence from randomized studies was downgraded from "high" to "low" due to: (1) a serious risk of bias in two studies that diminished the level of confidence in the observed effects, and (2) serious indirectness of the interventions and the comparisons being assessed.

[g] Includes **3 non-randomized controlled intervention studies** (Pangrazi et al. 2003; Williams and Warrington 2011; Sigmundova and Sigmund 2012) and **3 single group intervention studies** (Rowland et al. 1996; Duncan et al. 2012; Huang et al. 2012).

[h] Serious risk of bias. Allocation concealment: Group assignment was based on completion of intervention or drop-out, with drop-outs serving as CTRL. Attrition bias: the large amount of missing data was likely related to the outcome of interest (Williams and Warrington 2011). Other source of bias: there was no CTRL group (Duncan et al. 2012; Huang et al. 2012). Attrition bias: Analysis did not control for clustering by class order/number and change scores were not compared with a reference group (Huang et al. 2012). Allocation concealment was not described. Performance bias: no blinding attempted. Other sources of bias: The authors reported implausibly large effect sizes for the intervention (i.e., a reduction in the proportion of obesity to 0% in INT, while the proportion doubled in CTRL) (Sigmundova and Sigmund 2012). Incomplete outcome data: dietary analysis showed there was a small increase in caloric intake in INT compared to CTRL that was not controlled for in analysis (Rowland et al. 1996).

[i] Serious indirectness. Differences in intervention: Studies examined various types of physical activity programs and provided indirect evidence bearing on the potential effectiveness of different intensities and durations of physical activity. Indirect comparisons: different durations and intensities of physical activity were not compared within individual studies.

[j] The quality of evidence from non-randomized intervention studies was downgraded from "low" to "very low" due to: (1) a serious risk of bias in four studies that diminished the level of confidence in the observed effects, and (2) serious indirectness of the interventions and the comparisons being assessed.

[k] Includes **14 longitudinal studies** (Stevens et al. 2004; Janz et al. 2005; Stevens et al. 2007; Butte et al. 2007a; Janz et al. 2009; Riddoch et al. 2009; Treuth et al. 2009; Basterfield et al. 2012; Hallal et al. 2012; White and Jago 2012; Mitchell et al. 2013; Carson et al. 2014; Hjorth et al. 2014a; Hjorth et al. 2014b) from **11 unique samples**; Janz et al. 2005 and 2009 reported data from the Iowa Bone Development Study; Stevens et al. 2007 and Treuth et al. 2009 reported data from the TAAG study; Hjorth et al. 2014a and 2014b reported data from the OPUS study. Results are presented separately, and participants are only counted once.

[l] Serious risk of bias. Authors reported significance at p<0.10. It is unclear if data from the univariate or multivariate models are reported. Loss to follow-up not examined by fat mass index (Basterfield et al. 2012). Enrollment protocol was not adequately described. Adiposity outcomes were reportedly estimated using a "previously validated equation", however in the validation study BMI was a better predictor of BF than the new equation. In the overweight group, baseline PA was a significant predictor of fat mass and fat-free mass, but not %BF; this is concerning as %BF is a function of fat mass and fat-free mass (Stevens et al. 2004). Sixty-eight percent of participants did not provide valid baseline accelerometer data or did not have complete cardiometabolic risk factor data (which included WC) at baseline and/or follow-up; reasons for missing data were not provided. Those lost to follow-up were older, heavier and displayed

lower cardiorespiratory fitness levels than completers. Conditional BMI Z-score velocity was validated with infants as cited, however the validity and reliability with children and youth are unknown (Carson et al. 2014). Reasons for exclusions are not adequately reported (Hallal et al. 2012). Reasons for missing outcome data not clear (Riddoch et al. 2009). Only the subset that gained weight was included in the analysis (n=798 out of n=879), which may have affected the associations reported (Butte et al. 2007a).

[m] The quality of evidence from longitudinal studies was not upgraded from "low" to "moderate" due to serious risk of bias.

[n] Includes **48 studies** (Ekelund et al. 2004; Andersen et al. 2006; Duncan et al. 2006; Ekelund et al. 2006; Lohman et al. 2006; Ness et al. 2007; Ortega et al. 2007; Stevens et al. 2007; Hurtig-Wennlof et al. 2007; Duncan et al. 2008; Hands and Parker 2008; Lohman et al. 2008; Hands et al. 2009; Mark and Janssen 2009; Riddoch et al. 2009; Steele et al. 2009; Treuth et al. 2009; Ferrar and Olds 2010; Martinez-Gomez et al. 2010b; Owen et al. 2010; Ortega et al. 2010; Dollman et al. 2010; Kelly et al. 2010; Belcher et al. 2010; Peart et al. 2011; Holman et al. 2011; Kwon et al. 2011; Mark and Janssen 2011; Tudor-Locke et al. 2011; Ruiz et al. 2011; Sayers et al. 2011; Chung et al. 2012; Grydeland et al. 2012; Lawman et al. 2012; Martinez-Gomez et al. 2012; Mendoza et al. 2012; Barreira et al. 2013; Carson et al. 2013; Ekstedt et al. 2013; St George et al. 2013; Taverno Ross et al. 2013; Manios et al. 2013; Jimenez-Pavon et al. 2013a; Jimenez-Pavon et al. 2013c; da Silva et al. 2014; Young et al. 2014; Katzmarzyk et al. 2015a; Katzmarzyk et al. 2015b) from **19 unique samples**. **Two studies** reported data from the Western Australia Child and Adolescent PA and Nutrition Survey 2003 (Hands and Parker 2008 and Hands et al. 2009); **9 studies** reported data from NHANES (Belcher et al. 2010; Holman et al. 2011; Chung et al. 2012; Barreira et al. 2013; Carson et al. 2013; Mark and Janssen 2009 and 2011; Mendoza et al. 2012 and Peart et al. 2011); **2 studies** reported data from the ACT Trial (Lawman et al. 2012 and St George et al. 2013); **6 studies** reported data from the EYHS (Andersen et al. 2006; Ortega et al. 2007; Ortega et al. 2010; Ekelund et al. 2004 and 2006; and Hurtig-Wennlof et al. 2007); **2 studies** reported data from ISCOLE (Katzmarzyk et al. 2015a and 2015b); **3 studies** reported data from ALSPAC (Ness et al. 2007; Riddoch et al. 2009 and Sayers et al. 2011); **2 studies** reported data from the Australian National Children's Nutrition and PA survey (Ferrar and Olds 2010 and Dollman et al. 2010); **6 studies** reported data from TAAG (Stevens et al. 2007; Treuth et al. 2009; Kelly et al. 2010; Young et al. 2014; and Lohman et al. 2006 and 2008); **4 studies** reported data from HELENA (Ruiz et al. 2011; Martinez-Gomez et al. 2010b and 2012; and Jimenez-Pavon et al. 2013a); Duncan et al. 2006 and 2008 were from the same sample; results are reported separately and participants are only counted once.

[o] Serious risk of bias. Potential confounders were not controlled for (da Silva et al. 2014; Katzmarzyk et al. 2015b). Reasons for missing PA and BMI data were not reported (daSilva et al. 2014). The amount of missing data/exclusions and reasons were not reported (Hurtig-Wennlof et al. 2007; Duncan et al. 2008). Risk of detection bias as participants were retained if they provided PA data for at least 1 to 7 days; 68% provided at least 5 days of PA data and 32% provided 1-4 days. PA levels were slightly higher in those with fewer days of PA data. MVPA and LPA were recorded but not reported (Owen et al. 2010). Reasons for missing data were not explained (Steele et al. 2009). Participants with missing PA data differed on some outcome measures (Andersen et al. 2006). BMI z-score was measured and analyzed for males and females 5-12 yr and collected but not reported for 13-16 yr olds (Dollman et al. 2010). Parent-estimated height and weight were used (Tudor-Locke et al. 2011). Thirty percent of adiposity data were missing without explanation (Jimenez-Pavon et al. 2013c). A large proportion of data were missing with no explanation (Ruiz et al. 2011; Sayers et al. 2011; Taverno Ross et al. 2013). FFM and FM were estimated using an equation developed specifically for the study, however a methods paper showed the equation did not perform satisfactorily or meet the criteria for cross-validation (Taverno Ross et al. 2013). Validity and reliability of outcome measure is unknown and a reference for the equation is not provided (Young et al. 2014).

[p] Serious inconsistency. Findings for LPA were highly inconsistent. Findings for other intensities of PA consistently reported null or favourable associations between PA and adiposity outcomes. Consistency for other measures was not an issue, with consistency and strength of findings explained by varied outcome measurement and intensity of PA (stronger associations for higher intensities of PA and more precise measures of adiposity).

[q] The quality of evidence from cross-sectional studies was downgraded from "low" to "very low" due to: (1) serious risk of bias in 14 studies that diminished the level of confidence in the observed effects and (2) serious unexplained inconsistency in the findings for LPA.

Table A.1.e. Adverse effects and physical activity, children and adolescents

Questions: What is the association between **physical activity** and health-related outcomes? Is there a dose response association (volume, duration, frequency, intensity)? Does the association vary by type or domain of PA?
Population: Children aged 5-under 18 years of age
Exposure: Greater volume, duration, frequency, or intensity of physical activity
Comparison: No physical activity or lesser volume, duration, frequency, or intensity of physical activity
Outcome: Adverse effects
*__Importance__: CRITICAL

Black font is from original GRADE Evidence Profiles from Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (12-17 years).*(6)* Red font denotes additions based on WHO update using review of existing systematic reviews.

	Quality Assessment							
No. of studies/ Study design **No. of participants**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other**	**Summary of findings**	**Certainty**	**US PAGAC evidence and conclusions *(30)***
The range of mean ages was 10 to 15 years. Data were collected longitudinally which up to 19 months of follow-up. Measures included spinal pain occurrences. Outcomes were measured subjectively (self-report) or objectively (clinical examination and audit of linked medical records).								
2 Longitudinal[a] n=2,101 **No eligible reviews identified.**	Serious risk of bias	Serious inconsistency	No serious indirectness	No serious imprecision	None	*Total PA* **1/2 studies** reported unfavourable association with **diagnosed** or **traumatic spinal pain** (Franz et al. 2017). **1/2 studies** reported null associations with **self-reported number of spinal pain sites** and **frequency of spinal pain** (Aartun et al. 2016). *LPA* **1 study** reported unfavourable association between *% time in LPA* with **self-reported spinal pain** (Franz et al. 2017) *MPA* **1 study** reported null associations between *% time in MPA* with **self-reported** or **diagnosed spinal pain** (Franz et al. 2017). *MVPA* 1 study reported null associations between *total MVPA* or *meeting at least 1 hour/d of MVPA* with **self-reported number of spinal pain sites** and **frequency of spinal pain** (Aartun et al. 2016). *VPA* **1/2 studies** reported unfavourable associations between *% time in VPA* with **diagnosed or traumatic spinal pain** (Franz et al. 2017); **1/2 studies** reported null	VERY LOW[b]	Outcome not included

						associations between *total VPA* with **self-reported number of spinal pain sites** and **frequency of spinal pain** (Aartun et al. 2016).		

Abbreviations: LPA = light intensity physical activity; MPA = moderate physical activity; MVPA = moderate-and-vigorous physical activity; PA = physical activity; VPA = vigorous physical activity.

[*] As determined by WHO

[a] Includes **2 longitudinal studies** (Aartun et al. 2016; Franz et al. 2017).

[b] The quality of evidence from longitudinal studies was not upgraded from "low" to "moderate" due to serious risk of bias and was downgraded from "low" to "very low" due to inconsistency across studies.

Table A.1.f. Mental health and physical activity, children and adolescents

Questions: What is the association between **physical activity** and health-related outcomes? Is there a dose response association (volume, duration, frequency, intensity)? Does the association vary by type or domain of PA?
Population: Children aged 5-under 18 years of age
Exposure: Greater volume, duration, frequency, or intensity of physical activity
Comparison: No physical activity or lesser volume, duration, frequency, or intensity of physical activity
Outcome: Mental health (e.g., depressive symptoms, self-esteem, anxiety symptoms, ADHD)
*__Importance__: CRITCAL

Black font is from original GRADE Evidence Profiles from Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (12-17 years).*(6)* Red font denotes additions based on WHO update using review of existing systematic reviews.

	Quality Assessment							
No. of studies/ Study design **No. of participants**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other**	**Summary of findings**	**Certainty**	**US PAGAC evidence and conclusions** ***(30)***
The range of mean ages was 12.0 to 16.9 years. Data were collected cross-sectionally and with 3-year follow-up. Psychological distress was assessed as depressed mood by self-reported MFQ, depressive symptoms by self-reported short-MFQ and CES-D and MDD by face-to-face interview using sections of the Schedule for Affective Disorders and Schizophrenia for School Age Children-Present and Lifetime Version.								
1 Longitudinal[a] n=736 **No eligible reviews identified.**	No serious risk of bias	Unable to assess	No serious indirectness	No serious imprecision	None	No association between baseline **MVPA** or **PAEE** and **depressed mood** or **Major Depressive Disorder** at follow-up (Toseeb et al. 2014).	LOW[b]	5 ESRs Insufficient evidence is available to determine the relationship between physical activity and anxiety among youth. **PAGAC Grade: Not assignable**. 4 ESRs, 1 review of reviews Strong evidence demonstrates that physical activity reduces the risk of experiencing depression. **PAGAC Grade: Strong.**
4 Cross-sectional[c] n=10,641 **No eligible reviews identified.**	No serious risk of bias	Serious inconsistency [d]	No serious indirectness	No serious imprecision	None	***Total PA:*** associations were null (**2/3 studies;** Johnson et al. 2008; Toseeb et al. 2014), or mixed (null and favourable) depending on if assignment to tertiles adjusted for total PA or adjusted for %time in MVPA (**1/3 studies;** Wiles et al. 2012). ***VPA:*** null associations (**1/1 studies;** Johnson et al. 2008). ***MVPA:*** associations were favourable (**1/4 studies;** Wiles et al. 2012), null (**2/4 studies;** Johnson et al. 2008; Toseeb et al. 2014), or mixed (null and unfavourable; **1/4 studies;** Young et al. 2014). ***LPA:*** null associations (**1/1 studies;** Johnson et al. 2008).	VERY LOW[e]	

								Strong evidence demonstrates that physical activity interventions reduce depressive symptoms in individuals with and without major depression across the lifespan. **PAGAG Grade: Strong**.

Abbreviations: CES-D = Center for Epidemiological Studies-Depression Scale; MDD = Major Depressive Disorder; MFQ = Mood and Feelings Questionnaire; MVPA = moderate to vigorous physical activity; PA = physical activity; PAEE = physical activity energy expenditure.

[*] As determined by WHO

[a] Includes **1 longitudinal study** (Toseeb et al. 2014).

[b] The overall quality of evidence from longitudinal studies was upgraded from "low" to "moderate" due to no serious risk of bias but downgraded to "low" due to inability to assess consistency (1 study).

[c] Includes **4 cross-sectional studies** (Johnson et al. 2008; Wiles et al. 2012; Toseeb et al. 2014; Young et al. 2014) from **3 unique samples**. **Two studies** (Johnson et al. 2008; Young et al. 2014) report data from the TAAG study. Results are reported separately and participants are only counted once.

[d] Serious inconsistency. Inconsistency is related to the associations between MVPA and depressive symptoms/depressed mood; favourable, null and unfavourable associations were reported in four studies, with no clear reason for differences (Johnson et al. 2008; Wiles et al. 2012; Toseeb et al. 2014; Young et al. 2014).

[e] The quality of evidence from cross-sectional studies was downgraded from "low" to "very low" due to unexplained inconsistency among the findings.

Table A.1.g. Cognitive outcomes and physical activity, children and adolescents

Questions: What is the association between **physical activity** and health-related outcomes? Is there a dose response association (volume, duration, frequency, intensity)? Does the association vary by type or domain of PA?
Population: Children aged 5-under 18 years of age
Exposure: Greater volume, duration, frequency, or intensity of physical activity
Comparison: No physical activity or lesser volume, duration, frequency, or intensity of physical activity
Outcome: Cognitive outcomes (e.g., academic performance, executive function)
*__Importance__: CRITCAL

Black font is from original GRADE Evidence Profiles from Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (12-17 years).*(6)* Red font denotes additions based on WHO update using review of existing systematic reviews.

	Quality Assessment							
No. of studies/ Study design No. of participants	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other**	**Summary of findings**	**Certainty**	**US PAGAC evidence and conclusions** ***(30)***
The range of mean ages was 7.8 to 16.9 years. Data were collected by RCT, non-randomized intervention trial, cross-sectionally and up to ~~5~~ 6 years of follow-up. Cognitive Development / Academic Achievement were assessed by: WIAT-III, TEA-Ch, CDR, computerized cognitive assessment system, d2 Test of Attention, Letter Digit Substitution Test, BAS, Trail Making Test, Stroop Color and Word Test, Verbal Fluency Test, WISC-IV, WAI, OSPAN, The Tower of London, school records and GPA, and state or national level standardized tests. Mathematics Engagement was assessed using School Engagement Measure. On-task Behaviour was assessed through systematic direct observation. All outcomes were measured objectively.								
4 RCTs n=2,847	Serious risk of bias	No serious inconsistency	Serious indirectness	No serious imprecision	Possibility of publication bias Most trials did not address higher level EF measures	Xue et al. 2018 *(29)* (19 RCTs; n = 5,038): Exercise interventions with multiple sessions per week for 6 weeks or longer were associated with greater change in overall EF (SMD 0.20 [95% I, 0.09 to 0.30], *p*<0.05), inhibitory control (SMD 0.26 [95% CI, 0.08 to 0.45], *p*<0.01), working memory (SMD 0.10 [95% CI, -0.05 to 0.25], *p*<0.02), and cognitive flexibility (SMD 0.14 [95% CI, -0.03 to 0.31], *p*<0.04) compared with no exercise interventions. There was no evidence of an effect on planning. Effects of exercise interventions was comparatively larger on populations with higher versus lower BMIs. Martin et al. 2017 *(21)*: (3 RCTs, 2 NRTs; n=2,204): Mixed effects of classroom-based PA vs. no PA on measures of learning, reasoning, math, reading, fluid intelligence social studies, and math, science, and English. __On-task behaviour__ **3 studies** found positive effects of PA intervention on on-task behaviour (Bartholomew et al. 2018; Riley et al. 2016; Grieco et al. 2016). __Cognition__ **1 study** found no difference between PA intervention and control groups for **content recall** (Norris et al. 2015).	MODERATE[m]	9 ESRs Moderate evidence indicates an effect of both acute and long-term moderate-to-vigorous physical activity interventions on brain, cognition, and academic outcomes (e.g., school performance, psychometric profile of memory and executive function) in preadolescent children ages 5 to 13 years. **PAGAC Grade: Moderate.**

						Academic achievement **1 study** found no change on **mathematical test performance** following the PA intervention (Riley et al. 2016).		Insufficient evidence is available to determine whether a relationship exists between moderate-to-vigorous physical activity and cognition in adolescents ages 14 to 18 years. **PAGAC Grade: Not assignable.**
5 NRTs[a] n=547	Serious risk of bias[b]	No serious inconsistency	Serious indirectness[c]	No serious imprecision	NR	**On-task behaviour** **2/3 studies** showed positive effects of PA intervention on **on-task behaviour** (Goh 2017; Mullender-Wijnsma et al. 2015); **1/3 studies** showed no effects of PA intervention **on on-task behaviour** (Wilson et al. 2016). **Cognition** **2 studies** showed no effects of PA intervention on **sustained attention** or executive function text performance (**processing speed, selective attention)** (Wilson et al. 2016; van den Berg et al. 2016). **Academic Achievement** **GPA** increased in both groups, but there were no between-group differences (Shore et al. 2014).[d]	VERY LOW[e]	
9 Longitudinal[f] n=15,460 **No reviews limited to longitudinal studies identified.**	Serious risk of bias[g]	No serious inconsistency	No serious indirectness	No serious imprecision	NR	**Academic Achievement** **School Grades** *%MVPA* at age 11 yr was favourably associated with **English** (but not **Math** or **Science**), and with academic attainment at age 13 and 16 in boys and girls (association also significant for **Science** in girls at age 16 yr) (Booth et al. 2014). **1 study** found null association between *MVPA* and **Grade based points** (Corder et al. 2015). **Standardized tests** 1 study found *PA index* was favourably associated with **writing** score, but not **reading** or **numeracy** (Telford et al. 2012b). **1 study** found that changes in *MVPA* had mixed favourable (in girls) and null (in boys) associations with changes in **NAPLAN test scores** (Owen et al. 2018). **1 study** found null associations between *total PA (cpm)* or *% time in MVPA* with **numeracy, reading** and **English** (Aadland et al. 2017). **Cognition** **Executive function tests (CDR):** **1 study** found no association between *total PA* or *% time in MVPA* at age 11 yr and test speed or accuracy at age 13. In boys, *%MVPA* (adjusted for total PA) was favourably associated with accuracy, but not speed. In girls, no association with speed or accuracy (Booth et al. 2013). **1 study** found no associations between *total PA (cpm)* or *% time in MVPA* with **inhibition, working memory** and **cognitive flexibility** (Aadland et al. 2017). **1 study** found unfavourable associations between *LPA* and **verbal reasoning** and **verbal knowledge**, while mixed unfavourable and null associations for *MVPA* (Aggio et al. 2016). **1 study** found mixed unfavourable (in girls) and null (in boys) associations between *LPA* and **fluid intelligence**; and mixed unfavourable (in boys) and null (in girls) associations between *VPA* and **inhibitions** (Wickel et al. 2017).	LOW[h]	

						1 study found null associations between *LPA* with **inhibition** and **working memory**, between *MPA or MVPA* **with inhibition, working memory** and **fluid intelligence**; and between *VPA* with **working memory** and **intelligence** (Wickel et al. 2017) **Mathematics Engagement** **1 study** found that changes in *MVPA* had null association with changes in **mathematics engagement** (Owen et al. 2018a). **1 study** found null associations between *LPA, MPA, VPA* and *MVPA* with **mathematics engagement**. (Owen et al. 2018b) **1 study** found mixed favourable associations between *MPA* and **cognitive engagement**, and null associations with **behavioural, emotional and overall school engagement**. (Owen et al. 2018b)		
6 Cross-sectional[i] n=11,996	Serious risk of bias[j]	Serious inconsistency[k]	No serious indirectness	No serious imprecision		Marques et al. 2016 *(20)* (41 cross-sectional studies, 2 RCTs, and 8 longitudinal studies; n = NR): There was no consistent evidence of a relationship between objectively-measured PA and academic outcomes (**4/11 studies** found statistically significant positive association; **1/11 study** found an inverse relationship; **6/11 studies** reported no relationship). **12/18 studies** reported statistically significant associations between self-reported PA and academic measures and **6/18 studies** found no relationship. **Academic Achievement** **Standardized tests** **Total PA** **2/2 studies** reported no association between *total PA* and WIAT-III (Lambourne et al. 2013; Hansen et al. 2014). **MPA, MVPA, VPA** **1/3 studies** reported mixed unfavourable and null associations between *MVPA* and **state Math test** performance with inconsistencies occurring across samples (Young et al. 2014). **1/3 studies** reported mixed favourable and null associations, with *%MVPA* favourably associated with **English** (but not **Math** or **Science**) scores in boys, and **English** and **Science** (but not **Math**) scores in girls (Booth et al. 2014). **School Grades** **1/3 studies** found *MPA, MVPA* and *VPA* were unfavourably associated with **Math** and **Language scores,** and **GPA** (Esteban-Cornejo et al. 2014). **Cognition** **Total PA and MVPA** **Executive function tests (TEA-Ch, CDR)** **1/1 studies** reported mixed null and favourable associations between *total PA* or *%MVPA* and **test speed and accuracy** (Booth et al. 2013).	VERY LOW[l]	

Note: CDR = Cognitive Drug Research; EF = executive function; GPA = grade point average; MPA = moderate intensity physical activity; MVPA = moderate-to-vigorous physical activity; NR = not reported; NRT = non-randomized trial; PA = physical activity; SMD = standardized mean difference; TEA-Ch = Test of Everyday Attention for Children; VPA = vigorous intensity physical activity; WIAT-III = Weschsler Individual Achievement Test of oral language, written language and mathematics-Third Edition.

[*]As determined by WHO

[a] Includes **1 non-randomized trial** (Shore et al. 2014).

[b] Serious risk of bias. No inclusion/exclusion criteria established; inadequate reporting of recruitment, allocation concealment, and blinding; large unexplained loss to follow-up (36.5% retention) and unknown if follow-up differed by group allocation (Shore et al. 2014).

[c] Serious indirectness. Differences in intervention: studies examined PE class content and provided indirect evidence bearing on the potential effectiveness of different intensities and durations of PA. Indirect comparisons: different durations and intensities of PA were not compared within individual studies.

[d] The intervention group increased steps/day (baseline to post-intervention: 9692 to 12307) more than the control group (9420 to 10608) (Shore et al. 2014).

[e] The quality of evidence from the non-randomized study was downgraded from "low" to "very low" due to: (1) a serious risk of bias that diminished the level of confidence in the observed effects, and (2) serious indirectness of the intervention and the comparison being assessed.

[f] Includes **3 longitudinal studies** (Telford et al. 2012b; Booth et al. 2013; Booth et al. 2014) from **2 unique samples**. **Two studies** reported data from the ALSPAC sample (Booth et al. 2013; Booth et al. 2014); results are reported separately, and participants are only counted once.

[g] Serious risk of bias. Validity and reliability of outcomes unknown (Telford et al. 2012b; Booth et al. 2013; Booth et al. 2014).

[h] The quality of evidence from the longitudinal studies was not upgraded from "low" to "moderate" due to serious risk of bias.

[i] Includes **6 cross-sectional studies** (Lambourne et al. 2013; Booth et al. 2013; Esteban-Cornejo et al. 2014; Young et al. 2014; Booth et al. 2014; Hansen et al. 2014) from **5 unique samples**. **Two studies** reported data from the ALSPAC sample (Booth et al. 2013; Booth et al. 2014); results are reported separately, and participants are only counted once.

[j] Serious risk of bias. Valid PA data missing for 41.5% of the sample (Hansen et al. 2014). Validity and reliability of outcomes unknown (Booth et al. 2013 and 2014; Esteban-Cornejo et al. 2014; Young et al. 2014).

[k] Serious inconsistency. **Two studies** found unfavourable associations [between PA (MPA, MVPA, VPA) and GPA (Esteban-Cornejo et al. 2014), and between MVPA and state Math test performance (Young et al. 2014)], **2 studies** found no associations [between total PA and WIAT-III (Lambourne et al. 2013; Hansen et al. 2014)], and **2 studies** found no or favourable associations [between PA (total, %MVPA) and executive function tests (Booth et al. 2013); and between %MVPA and national English, Math and Science test scores (Booth et al. 2014)].

[l] The quality of evidence from cross-sectional studies was downgraded from "low" to "very low" due to: (1) a serious risk of bias in five studies that diminished the level of confidence in the observed effects, and (2) large unexplained inconsistency among the findings.

[m] The quality of evidence from the RCT was downgraded from "high" to "moderate" due to: (1) a serious risk of bias that diminished the level of confidence in the observed effects, and (2) serious indirectness of the intervention and the comparison being assessed.

Table A.1.h. Prosocial behavior and physical activity, children and adolescents

Questions: What is the association between **physical activity** and health-related outcomes? Is there a dose response association (volume, duration, frequency, intensity)? Does the association vary by type or domain of PA?
Population: Children aged 5-under 18 years of age
Exposure: Greater volume, duration, frequency, or intensity of physical activity
Comparison: No physical activity or lesser volume, duration, frequency, or intensity of physical activity
Outcome: Prosocial behaviour (e.g., conduct problems, peer relations, social inclusion)
***Importance**: IMPORTANT

Black font is from original GRADE Evidence Profiles from Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (12-17 years).*(6)* Red font denotes additions based on WHO update using review of existing systematic reviews.

	Quality Assessment							
No. of studies/ Study design **No. of participants**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other**	**Summary of findings**	**Certainty**	**US PAGAC evidence and conclusions** ***(30)***
The range of mean age was 6.0 to 11.15 years; data were collected by RCT, non-randomized intervention trials, cross-sectionally and up to 4 years of follow-up. Prosocial behaviour, conduct problems and peer problems were assessed via the Strengths and Difficulties Questionnaire, Effort and time on task were assessed via the Classroom Behavior and Assets Scale, Social acceptance was assessed via Harter's Self-perception Profile for Children and time in play and social skills were assessed via The Social Skills Improvement System Rating Scale and The Pictorial Scale of Perceived Competence and Social Acceptance for Young Children. All outcomes were measured objectively.								
1 RCT[a] n=226 **No eligible reviews identified.**	Serious risk of bias	Unable to assess	No serious indirectness	No serious imprecision	None	There was no effect of MVPA on time in play and social skills (Bundy et al. 2017).	LOW[f]	Outcome not included
1 NRT[b] n=1,322 **No eligible reviews identified.**	Serious risk of bias	Unable to assess	No serious indirectness	No serious imprecision	None	There were positive effects of MVPA on effort and time on task (Carlson et al. 2015)	VERY LOW[g]	
1 Longitudinal[c] n=7,704	Serious risk of bias	Unable to assess	No serious indirectness	No serious imprecision	None	PA associated with fewer peer problems. MVPA– unfavourable association with conduct hyperactivity problems (boys & girls) & conduct problems (boys only) (Ahn et al. 2018)	VERY LOW[h]	

No eligible reviews identified.								
1 Cross-sectional[d] n=652 **No eligible reviews identified.**	Serious risk of bias[e]	Unable to assess	No serious indirectness	No serious imprecision	None	There was no association between *total PA* and **prosocial behaviour**, **peer problems**, **social acceptance** or **conduct problems** for boys or girls (Sebire et al. 2011). *MVPA* was favourably correlated with **peer problems** and **social acceptance** (in boys, not girls). *MVPA* was favourably associated with **prosocial behaviour** (in girls, not boys). *MVPA* was not associated with **conduct problems** in boys or girls.	VERY LOW[i]	

Abbreviations: MVPA = moderate-to-vigorous physical activity; PA = physical activity

[*]As determined by WHO
[a] Includes **1 RCT study** (Bundy et al. 2017)
[b] Includes **1 NRT study** (Carlson et al. 2015)
[c] Includes **1 longitudinal study** (Ahn et al. 2018)
[d] Includes **1 cross-sectional study** (Sebire et al. 2011).
[e] Serious risk of bias. Complete data for only 66% of participants; no indication that data were missing at random. Internal consistency of the scales was questionable (alpha = 0.60 to 0.66).
[f] The qualtiy of evidence from this RCT was downgraded from "high" to "low" due to a serious risk of bias that diminished the level of confidence in the observed effects and because inconsistency could not be assessed (1 study).
[g] The quality of evidence from this NRT was downgraded from "low" to "very low" due to a serious risk of bias that diminished the level of condifence in the observed effects and because inconsistency could not be assessed (1 study).
[h] The quality of evidence from this longitudinal study could not be upgraded from "low" to "moderate" due to serious risk of bias that diminished the level of condifence in the observed effects and was downgraded from "low" to "very low" because inconsistency could not be assessed (1 study).
[i] The quality of evidence from this cross-sectional study was downgraded from "low" to "very low" due to a serious risk of bias that diminished the level of confidence in the observed effects and because inconsistency could not be assessed (1 study).

Table A.1.I. Sleep duration and quality and physical activity, children and adolescents

Questions: What is the association between **physical activity** and health-related outcomes? Is there a dose response association (volume, duration, frequency, intensity)? Does the association vary by type or domain of PA?
Population: Children aged 5-under 18 years of age
Exposure: Greater volume, duration, frequency, or intensity of physical activity
Comparison: No physical activity or lesser volume, duration, frequency, or intensity of physical activity
Outcome: Sleep duration and quality
***Importance**: IMPORTANT

No GRADE Evidence Profiles from Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (12-17 years)*(6)* and no systematic reviews identified by WHO.

A.2. Sedentary Behavior

Table A.2.a. Physical fitness and sedentary behavior, children and adolescents

Questions: What is the association between **sedentary behaviour** and health-related outcomes? Is there a dose response association (total volume and the frequency, duration and intensity of interruption)? Does the association vary by type and domain of sedentary behaviour?
Population: Children aged 5-under 18 years of age
Exposure: Greater volume, decreased frequency, duration or intensity of interruption of sedentary behaviour
Comparison: Lesser volume, increased frequency, duration or intensity of interruption of sedentary behaviour
Outcome: Physical fitness (e.g., cardiorespiratory, motor development, muscular fitness)
***Importance**: CRITICAL

Black font is from original GRADE Evidence Profiles from Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (12-17 years).*(6)* Red font denotes additions based on WHO update using review of existing systematic reviews.

	Quality Assessment							
No. of studies/ Study design **No. of participants**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other**	**Summary of findings**	**Certainty**	**US PAGAC evidence and conclusions** *(30)*
Mean baseline age ranged between 6.7 and 17.7 years; where mean age was not reported, baseline age ranged from 6 to 18.5 years. Data were collected from longitudinal (n=3) and cross-sectional (n=18) study designs with up to 2 year follow up. Fitness was assessed as CFR (Andersen test, PACER, AMIS 2001 Cardiopulmonary Function test, FITNESSGRAM 20 m shuttle-run, submaximal cycle ergometer test, 3 minute step test, Leger shuttle run, Physical Work Capacity 170 test); flexibility (EUROFIT test, Dordel-Koch test, Motorik-Modeule, FITNESSGRAM); muscular strength/endurance (EUROFIT test, Dordel-Koch test, hand grip strength, Motorik-Modeule, FITNESSGRAM); power (EUROFIT test, Dordel-Koch test). All outcomes were measured objectively.								
3 Longitudinal[a] n = 4,327 **No eligible reviews identified.**	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	Dose-response gradient[b]	**CRF** For prospective findings, higher sedentary behaviour was associated with lower fitness for: 1) Accelerometer-derived sedentary time - *1/1 study*. 2) Screen time - *3/3 studies*.	MODERATE[f]	Outcome not included
18 Cross-sectional[c] n = 55,636[e] **No eligible reviews identified.**	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	Exposure/outcome gradient[d]	**CRF** Higher sedentary behaviour was associated with lower fitness for: 1) Accelerometer-derived sedentary time - *2/5 studies* (only in females for 1 study). 2) Screen time - *3/3 studies.* 3) TV - 3/3 studies (only in females for 1 study). 4) Video game - *2/2 studies* (only for males on weekdays in 1 study). 5) Computer - *0/1 study.* *6) Total sedentary behaviour – 1/1 study.*	MODERATE[g]	

						Muscular Strength/Endurance Higher sedentary behaviour was associated with lower fitness for: 1) Accelerometer-derived sedentary time - *0/1 study.* 2) Screen time - *2/2 studies.* 3) TV - *1/3 studies* (not for grip strength in 1 study). 4) Computer - *2/2 studies* (not for strength of arm in 1 study). 5) Video game - *0/2 studies.* **Flexibility** Higher sedentary behaviour was associated with lower fitness for: 1) Accelerometer-derived sedentary time - *0/1 study.* 2) Screen time - *1/1 study.* 3) Computer - *1/1 study.* **Other** Higher sedentary behaviour was associated with lower fitness for: 1) Accelerometer-derived sedentary time and peak expiratory flow - *0/1 study.* 2) Screen time and overall fitness score - *1/1 study.* 3) TV and overall fitness score - *1/1 study.* 4) TV and higher resting HR - *1/1 study.*		

Abbreviations: CRF = cardiorespiratory fitness; HR = heart rate; TV = television viewing.

[*]As determined by WHO
[a]Includes 3 longitudinal studies *(31-33)*.
[b]A dose-response gradient of higher screen time with lower fitness was observed in 1 longitudinal study *(33)*.
[c]Includes 18 cross sectional study *(34-51)*.
[d]A gradient of higher accelerometer-derived sedentary time, screen time, or TV with lower fitness was observed in 7 cross-sectional studies *(35, 38, 41, 43, 46, 48, 49)*.
[e]Two studies used the German Health Interview and Examination Survey for Children and Adolescents *(43, 46)*.
[f]The quality of evidence for longitudinal studies was upgraded to "moderate" from "low" due to no serious risk of bias.
[g]The quality of evidence for cross-sectional studies was upgraded to "moderate" from "low" due to an exposure/outcome gradient.

Table A.2.b. Cardiometabolic health and sedentary behavior, children and adolescents

Questions: What is the association between **sedentary behaviour** and health-related outcomes? Is there a dose response association (total volume and the frequency, duration and intensity of interruption)? Does the association vary by type and domain of sedentary behaviour?
Population: Children aged 5-under 18 years of age
Exposure: Greater volume, decreased frequency, duration or intensity of interruption of sedentary behaviour
Comparison: Lesser volume, increased frequency, duration or intensity of interruption of sedentary behaviour
Outcome: Cardiometabolic health (e.g., blood pressure, dyslipidaemia, glucose, insulin resistance)
***Importance**: CRITICAL

Black font is from original GRADE Evidence Profiles from Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (12-17 years).*(6)* Red font denotes additions based on WHO update using review of existing systematic reviews.

	Quality Assessment							
No. of studies/ Study design **No. of participants**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other**	**Summary of findings**	**Certainty**	**US PAGAC evidence and conclusions** ***(30)***
Mean baseline age ranged between 6.7 and 16.7 years; where mean age was not reported, baseline age ranged from 5 to 19 years. Data were collected by longitudinal (n=6) and cross-sectional (n=25) study designs with up to 27 years follow up. Metabolic syndrome/cardiovascular disease risk factors were assessed as SBP, DBP, mean arterial BP, HbA1c, HOMA-IR, TG, HDL, TC/HDL ratio, metabolic syndrome risk score, insulin, glucose, non-HDL, resting heart rate, LDL, CRP, Matsuda insulin sensitivity, HOMA2-%B, OGTT-derived measures of insulin secretion (AUC I/$G_{t30\ min}$ and AUC I $G_{t120min}$), total cholesterol, apolipoprotein A1, apolipoprotein-B100, lipoprotein(a), adiponectin, leptin, VLDL TG, VLDL cholesterol, and HDL TG. All outcomes were measured objectively.								
12 Longitudinal[a] n = 23,834 **No eligible reviews identified.**	Serious risk of bias[b]	Serious inconsistency [c]	No serious indirectness	No serious imprecision	Dose-response gradient[d]	**Clustered Risk Score** Higher sedentary behaviour was associated with a higher clustered risk score for: 1) Accelerometer-derived sedentary time - *1/3 study*. 2) Screen time - *4/5 studies.* 3) TV - 2/2 studies. 4) Computer - *0/1 study.* **BP** Higher sedentary behaviour was associated with higher blood pressure for: 1) Accelerometer-derived sedentary time - *0/1 study*. 2) Screen time - *2/5 studies.* 3) TV - *1/3 studies.* 4) Computer - *2/2 studies (not for SBP in 2 studies).* 5) Video games - *0/1 studies.* **Cholesterol** Higher sedentary behaviour was associated with lower cholesterol for: 1) Accelerometer-derived sedentary time - *1/1 study (for HDL in 1 study).* 2) Screen time - 0/3 *studies.* 3) TV - *1/2 studies (for HDL in 1 study).*	LOW[e]	4 ESRs 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.**

						4) Computer - *0/1 study.* **Insulin** Higher sedentary behaviour was associated with higher insulin for: 1) Screen time - *1/1 study.* 2) TV - *1/1 study.* 3) Computer - *1/1 study.* **TG, HOMA-IR, Glucose, Other** Sedentary behaviour was not associated with other individual risk factors for the majority of studies.		
25 Cross-sectional[f] n = 69,342[j] **No eligible reviews identified.**	Serious risk of bias[g]	Serious inconsistency[h]	No serious indirectness	No serious imprecision	Exposure /outcome gradient[i]	**Clustered Risk Score** Higher sedentary behaviour was associated with a higher clustered risk score for: 1) Accelerometer-derived sedentary time - *1/3 studies.* 2) Long accelerometer-derived sedentary bouts (≥5 min) - *0/2 studies.* 3) Screen time - *3/3 studies* (only in females for 1 study). 4) TV - *6/10 studies* (only for females in 1 study). 5) Computer - *1/6 studies* (only for males in 1 study). 6) Video game - *1/3 studies* (only for males and weekends in 1 study). 7) Total sedentary behaviour – 0/2 studies. 8) Resting - *1/1 studies.* Higher sedentary behaviour was associated with a lower clustered risk score for: 1) Accelerometer-derived sedentary breaks - *1/2 studies.* 2) Short accelerometer-derived sedentary bouts (1-4 min) - *1/1 study.* **BP** Higher sedentary behaviour was associated with a higher BP for: 1) Accelerometer-derived sedentary time - *0/5 studies.* 2) Accelerometer-derived sedentary bouts - *0/2 studies.* 3) Accelerometer-derived sedentary breaks - 0/2 studies. 4) Screen time - *2/5 studies* (not for SBP in 1 study). 5) TV - *5/8 studies* (only males in 1 study and not for SBP in 1 study). 6) Computer - *1/6 studies.* 7) Video games - *1/3 studies* (not for SBP or mean atrial pressure in 1 study). 8) Total sedentary time - *0/2 studies.* Higher sedentary behaviour was associated with a lower BP for: 1) Reading - *1/2 studies.* 2) Homework - *1/1 study* (not for DBP or mean atrial pressure in 1 study). **Cholesterol** Higher sedentary behaviour was associated with a lower cholesterol for: 1) Accelerometer-derived sedentary time - *0/5 studies* 2) Accelerometer-derived sedentary bouts and breaks - *0/3 studies.* 3) Screen time - *1/4 studies (for HDL in 1 study).* 4) TV - *3/7 studies* (1 study was for non-HDL and 2 studies were HDL, no association with LDL in 2 studies or total cholesterol in 1 study).	VERY LOW[k]	

						5) Computer - *1/4 studies* (for HDL in 1 study, only in males for 1 study) 6) Video games - *0/1 study* 7) Total sedentary behaviour – 0/2 studies Higher sedentary behaviour was associated with a higher cholesterol for: 1) Listening to music - *1/1 study* (for HDL in 1 study). **TG, HOMA-IR, Insulin, Glucose, CRP, Other** Sedentary behaviour was not associated with other individual risk factors for the majority of studies.		

Abbreviations: TV = television viewing; HDL = high-density lipoprotein cholesterol; LDL = low-density lipoprotein cholesterol; VLDL, very low-density lipoprotein cholesterol, TG = triglycerides; SBP = systolic blood pressure; DBP = diastolic blood pressure; BP = blood pressure; HOMA-IR = homeostatic model assessment of insulin resistance; CRP = C-reactive protein; OGTT= Oral glucose tolerance test; HbA1c= glycated haemoglobin; TC=total cholesterol; AUC I = Area under the curve of insulin; min = minutes.

[*]As determined by WHO

[a]Includes 12 longitudinal studies *(52-57)*.

[b]Out of the 5 studies that used a subjective measure of sedentary behaviour, information on psychometric properties of the sedentary behaviour survey items were not provided.

[c]Mixed results observed. No serious inconsistency for screen time.

[d]A dose response gradient for higher screen time, sedentary time with higher cardiometabolic risk was observed for ~~5~~8 studies *(52, 54-57)*.

[e]The quality of evidence for longitudinal studies could not be upgraded from "low" due to serious risk of bias, was downgraded to "very low" due to serious inconsistency but upgraded to "low" due to a dose-response effect..

[f]Includes 25 cross-sectional studies *(42, 43, 58-80)*.

[g]Out of the 21 studies that used a subjective measure of sedentary behaviour, information on psychometric properties of the sedentary behaviour items were only provided in 6 studies *(43, 67, 73-76)*. One study did not report psychometric properties *(60)* but used the same sample of another study where psychometric properties were reported *(73)*.

[h]Mixed results observed.

[i]A gradient for higher TV, screen time, video games, computer, sedentary bouts, sedentary breaks, sedentary time with higher cardiometabolic risk was observed for 6 studies *(58, 60, 66, 76, 77, 80)* and lower risk for 2 studies *(61, 73)*.

[j]4 studies used data from the Quebec Adiposity and Lifestyle Investigation in Youth study *(60, 68, 69, 73)* and 2 studies used data from the German Health Interview and Examination Survey for Children and Adolescents study *(43, 59)*.

[k] The quality of evidence for cross-sectional studies was downgraded to "very low" from "low" due to serious risk of bias and serious inconsistency.

Table A.2.c. Bone health and sedentary behavior, children and adolescents

Questions: What is the association between **sedentary behaviour** and health-related outcomes? Is there a dose response association (total volume and the frequency, duration and intensity of interruption)? Does the association vary by type and domain of sedentary behaviour?
Population: Children aged 5-under 18 years of age
Exposure: Greater volume, decreased frequency, duration or intensity of interruption of sedentary behaviour
Comparison: Lesser volume, increased frequency, duration or intensity of interruption of sedentary behaviour
Outcome: Bone health
***Importance**: CRITICAL

Bone health outcomes not reviewed in Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (12-17 years) *(6)*. Red font denotes information from WHO update using review of existing systematic reviews.

	Quality Assessment							
No. of studies/ Study design No. of participants	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other**	**Summary of findings**	**Certainty**	**US PAGAC evidence and conclusions *(30)***
Mean age ranged between 2 and 24 years; most studies among school-aged children. Sedentary time was objectively measured by wearable monitors/accelerometers in 9/17 studies. SB was classified as <100 counts per minutes in all studies. Eight studies used only questionnaires to assess the type of SB including questions about average daily engagement in sedentary patterns such as time spent watching TV or using computers.								
17 observational studies[a] n = NR	Serious risk of bias[b]	No serious inconsistency	No serious indirectness	Serious imprecision	Not all studies adjusted for MVPA in analyses	Koedijk et al. 2017 *(16)*: **Lower extremity bone outcomes:** Consistent evidence of a negative association between objectively measured total sedentary time and lower extremity bone outcomes in school-aged children, independent of MVPA. **Lumbar spine bone outcomes:** No association observed between objectively measured total sedentary time and lumbar spine bone outcomes. **Total body bone outcomes:** Consistent evidence of no association between objectively measured total sedentary time and total body bone outcomes in school-aged children.	VERY LOW[c]	4 prospective cohort studies Limited evidence suggests that sedentary behavior is not related to bone health in children and adolescents. **PAGAC Grade: Limited.**

Abbreviations: MVPA = moderate-to-vigorous intensity physical activity; NR = not reported; SB = sedentary behaviour

*As determined by WHO
[a] Nine cross-sectional studies, six longitudinal prospective cohort studies, one longitudinal retrospective cohort study, and one case-control study.
[b] Only 3 of 17 studies were rated as high quality.
[c] The quality of evidence from observational studies could not be upgraded from "low" to "moderate" as there were serious limitations across studies and was downgraded from "low" to "very low" due to serious imprecision.

Table A.2.d. Adiposity/body composition and sedentary behavior, children and adolescents

Questions: What is the association between **sedentary behaviour** and health-related outcomes? Is there a dose response association (total volume and the frequency, duration and intensity of interruption)? Does the association vary by type and domain of sedentary behaviour?
Population: Children aged 5-under 18 years of age
Exposure: Greater volume, decreased frequency, duration or intensity of interruption of sedentary behaviour
Comparison: Lesser volume, increased frequency, duration or intensity of interruption of sedentary behaviour
Outcome: Adiposity/Body composition
***Importance**: CRITICAL

Black font is from original GRADE Evidence Profiles from Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (12-17 years).*(6)* Red font denotes additions based on WHO update using review of existing systematic reviews.

	Quality Assessment					**Summary of findings**	**Certainty**	**US PAGAC evidence and conclusions** *(30)*
No. of studies/ Study design **No. of participants**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other**			
Mean baseline age ranged between 5.0 and 16.7 years; where mean age was not reported, baseline age ranged from 3 to 19 years and grades 5 to 12. Data were collected by longitudinal (n=32), case-control (n=5), and cross-sectional (n=125) design with up to 12 years follow-up. Body composition was assessed as BMI (objectively measured, self-report, parental-report), BMI z-score (objectively measured, self-reported), BMI percentiles (objectively measured, self-reported), overweight and obesity (objectively measured, self-report, parental-report; International Obesity Task Force, Centre for Disease Control and Prevention, World Health Organization, other country-specific percentiles), WHtR (objectively measured), WHR (objectively measured), fat mass (TANITA bioelectric impedance, duel-energy x-ray absorptiometry, Lunar Prodigy DEXA scanner), WC (objectively measured), WC z-score (objectively measured), sum of skinfolds (objectively measured), % body fat (objectively measured), and overfat (slaughter equation).								
45 Longitudinal[a] n = 102,934[d]	Serious risk of bias[b]	No serious inconsistency	No serious indirectness	No serious imprecision	Dose-response gradient[c]	Among *prospective findings*, higher sedentary behaviour was associated with unfavourable body composition for: 1) Accelerometer-derived sedentary time – *5/18 studies* (1 study found higher waist circumference at follow-up was associated with higher sedentary time at baseline). 2) Accelerometer-derived breaks - *0/2 study*. 3) Screen time - *15/17 studies* (only for 6 and 10 yr. old's in 1 study, only in males for 1 study, not for waist circumference in 1 study). 4) TV - *15/18 studies* (only for females in 1 study, not for movie viewing in 1 study, not for movie viewing in males in 1 study, only for males and not for body fatness, waist circumference and skinfold thickness for males in 1 study). 5) Computer - *3/5 studies* (only for females in 1 study, not for waist circumference in 2 studies, not for body fatness, hip circumference, and BMI in 1 study). 6) Video game - *0/2 studies*. 7) Total sedentary behaviour - *0/1 study.* 8) Weekend internet use – 1/1 study Higher sedentary behavior was associated with better body composition 1) Accelerometer-derived sedentary time – *1/9 studies* (Higher total or uninterrupted SB (exposure and change) were associated with better body composition).	MODERATE[e]	8 ESRs 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.**

						2) Accelerometer-derived breaks - *1/2 study*. (Fragmentation findings were inconsistent – less fragmentation was beneficial overall (7-15y), but more fragmentation was beneficial between 9-12y		
5 Case-control[f] n = 4,748	No serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None.	Higher sedentary behaviour was associated with being overweight/obese (case group) for: 1) Screen time - *4/4 studies.* 2) TV - *2/2 studies (*only for weekends in 1 study). 3) Computer - *0/2 studies.*	LOW	
125 Cross-sectional[g] n = 1,386,706[j]	Serious risk of bias[h]	No serious inconsistency	No serious indirectness	No serious imprecision	Exposure /outcome gradient[i]	Fang et al. 2019 *(15)* (14 cross-sectional studies, 2 longitudinal studies, 1 case-control study; n = 45,381): Total screen time ≥2 hours/day was positively associated with childhood overweight/obesity compared with total screen time <2 hours/day (OR = 1.67 [95% CI, 1.48 to 1.88]). Marker et al. 2019 *(19)* (20 cross-sectional studies; n = 36,119)[m]: No statistically significant association between sedentary video gaming and body mass among children (correlation = 0.09 [95% CI, -0.07 to 0.25]) or adolescents (correlation = 0.01 [95% CI, -0.21 to 0.23]). Mohammadi et al. 2019 *(23)*: (2 cross-sectional studies; n=NR): **1/2 studies** found no association between screen time and BMI z-score; **1/2 studies** found a negative association between self-reported sedentary activities and risk of obesity among girls. Higher sedentary behaviour was associated with unfavourable body composition for: 1) Accelerometer-derived sedentary time - *3/18* studies (only after 3pm on weekdays for males in 1 study). 2) Long accelerometer-derived sedentary bouts (≥5 min) - *3/4 studies* (Only 5-9 minute bouts on weekdays and weekends only and in low MVPA group for only 5-9 minute and 10-19 minute bout on total days and weekends only in 1 study, Only 10-14 minute bouts for only BMI z-score and in males only in 1 study, and only at least 40 minutes (waist circumference only) in 11-14 yr old males after 3pm on weekdays and only at least 80 minutes for males only in 1 study). 3) Short accelerometer-derived sedentary bouts (1-4 minute) - *1/2 studies* (only for the weekend in 1 study). 4) Screen time - *26/36 studies* (only for males in 3 studies, not for urban participants in 1 study, not for certain ethnic groups in 1 study). 5) TV - *58/71 studies* (only for participates aged 4-8 yr in 1 study, only for males in 4 studies, only for females in 3 studies, only for weekdays in 1 study, only 12-18 yr old males for 1 study, not for BMI z-score in 1 study). 6) Computer - 7/*30 studies* (only for females in 2 studies). 7) Video game - 3/*20 studies* (only for weekends in 1 study and only for females in 1 study). 8) Total sedentary behaviour -*3/4 studies* (not for WC in 1 study, only in 1 sample and only for 6-11 yr olds in 1 study). 9) Homework - *3/7 studies* (only for males in 1 study, only in 6-11 yr old males in 1 study) 10) Quiet time - *1/1 study* (only for males in 1 study)	VERY LOW[k]	

						Higher sedentary behaviour was associated with favourable body composition for: 1) Accelerometer-derived sedentary time - *1/18 studies*. 2) Accelerometer-derived sedentary breaks - *2/4 studies (*only 11-14 yr old males after 3pm on weekdays in 1 study). 3) Short accelerometer-derived sedentary bouts (1-4 min) - *1/2 studies* (1-4 minute bouts in 1 study). 4) Long accelerometer-derived sedentary bouts (≥5 min) - *1/4 studies* (only for girls and only for WC in 1 study). 5) Screen time - *1/36 studies* 6) Computer - *2/30* studies (only for 1hr/day in 1 study, not for sum of skinfolds in 1 study). 7) Reading - *1/2 studies* (only for low group in 1 study) 8) Non-screen time - *1/1 study*.		
1 NRT[l]	Serious risk of bias	No serious inconsistency	No serious indirectness	Serious imprecision	None	No effect for total sitting (during class school or whole day). Effect for sitting in long bouts (>10 min) and number of sit-to-stand transitions. No effect for BMIz/WCz.	VERY LOW[e]	

Abbreviations: WHtR = waist to height ratio; WHR = waist to hip ratio; WC = waist circumference; BMI = body mass index; min= minutes; OR = odds ratio

[*]As determined by WHO

[a]Includes 45 longitudinal studies *(52, 53, 55, 56, 63, 81-107)*; Allen et al. 2016; Barrense-Dias et al. 2016; Collings et al. 2015; Griffiths et al. 2016; Janz et al. 2017; Mann et al. 2017; Marques et al. 2016; Oellingrath et al. 2016; Sluijs et al. 2016; Tanaka et al. 2018; Wheaton et al. 2015; Skrede et al. 2017; Dong et al. 2017)

[b]Out of the 26 studies that used a subjective measure of sedentary behaviour, only 7 studies mention psychometric properties for the sedentary behaviour items *(87, 90, 96, 98, 101, 102, 104)*.

[c]Dose response gradient was observed for higher TV, sedentary time, screen time, computer with unfavourable body composition in 14 studies *(52, 53, 55, 83, 90-92, 95, 97-99, 101, 102, 104)*.

[d]Two studies used the Longitudinal Study of Australian Children *(86, 91)*.

[e]The quality of evidence for longitudinal studies could not be upgraded from “low” to “moderate” due to serious risk of bias but was upgraded to “moderate” due to a dose-response.

[f]Includes 5 case-control studies *(108-112)*.

[g]Includes 125 cross-sectional studies *(34, 39, 42, 44, 47, 51, 58, 61, 62, 65, 73, 80, 91, 113-224)*.

[h] Out of 108 studies that used a subjective measure of sedentary behaviour only 33 studies mentioned psychometric properties for the sedentary behaviour items *(51, 87, 90, 96, 98, 101, 102, 104, 108-111, 116, 122, 128, 130, 147-150, 154, 156, 170, 181-183, 185, 188, 193, 194, 199, 211, 212)*.

[i] A gradient for higher TV, video games, sedentary bouts, sedentary breaks, screen time, studying with unfavourable body composition was observed in 30 studies *(62, 73, 80, 124, 128, 130, 131, 140, 151, 154, 158, 161, 173, 175-179, 185, 187, 191, 196, 197, 199, 205-207, 210, 214, 223)*.

[j]Two studies used the Gateshead Millenium Study *(82, 83)*. Two studies used the optimal well-being, development and health for Danish children through a health New Nordic Diet school meal study *(56, 88)*. Three studies used the Longitudinal Study of Australian Children *(91, 125, 126)*. Three studies used the China Health and Nutrition Survey *(202, 222, 223)*. Three studies used the Quebec Adiposity and Lifestyle Investigator in Youth study *(73, 134, 159)*. Two studies used the 2007-2009 Canadian Health Measures Survey *(62, 137)*. Three studies used the International Study of Childhood Obesity, Lifestyle and the Environment *(135, 170, 171)*. Two studies used the 2003/04 and 2005/06 National Health and Nutrition Examination Survey *(80, 194)*. Two studies used the Alimentación y Valoración del Estado Nutricional de los Adolescentes study *(47, 184)*]. Two studies used the Arab Teens Lifestyle Study *(113, 114)*.

[k]The quality of evidence for cross-sectional studies was downgraded to “very low” from “low” due to serious risk of bias.

[l]Includes one non-RCT (Allen et al. 2016)

[m] 15/20 studies were among children or adolescents.

Table A.2.e. Adverse effects and sedentary behavior, children and adolescents

Questions: What is the association between **sedentary behaviour** and health-related outcomes? Is there a dose response association (total volume and the frequency, duration and intensity of interruption)? Does the association vary by type and domain of sedentary behaviour?
Population: Children aged 5-under 18 years of age
Exposure: Greater volume, decreased frequency, duration or intensity of interruption of sedentary behaviour
Comparison: Lesser volume, increased frequency, duration or intensity of interruption of sedentary behaviour
Outcome: Adverse effects
*****Importance**: CRITICAL

No GRADE Evidence Profiles from Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (12-17 years)*(6)* and no systematic reviews identified by WHO.

Table A.2.f. Mental health and sedentary behavior, children and adolescents

Questions: What is the association between **sedentary behaviour** and health-related outcomes? Is there a dose response association (total volume and the frequency, duration and intensity of interruption)? Does the association vary by type and domain of sedentary behaviour?
Population: Children aged 5-under 18 years of age
Exposure: Greater volume, decreased frequency, duration or intensity of interruption of sedentary behaviour
Comparison: Lesser volume, increased frequency, duration or intensity of interruption of sedentary behaviour
Outcome: Mental health (e.g., depressive symptoms, self-esteem, anxiety symptoms, ADHD)
***Importance**: CRITCAL

Black font is from original GRADE Evidence Profiles from Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (12-17 years).*(6)* Red font denotes additions based on WHO update using review of existing systematic reviews.

	Quality Assessment							
No. of studies/ Study design **No. of participants**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other**	**Summary of findings**	**Certainty**	**US PAGAC evidence and conclusions** ***(30)***
Self-esteem								
Mean age ranged between 9.87 and 16.4 years; where mean age was not reported, age ranged from 12 to 19 years and grades 3 to 5. Data were collected by cross-sectional design (n=10). Self-esteem was assessed as overall/global/general and social self-esteem (Rosenberg Self-Esteem scale, Culture Free Self Esteem Inventories for Children, Marsh's Physical Self-Description questionnaire; Harter Self-Perception Profile for Children questionnaire, Harter's Self-Competence scale); general self-efficacy (Rosenberg's Self-Efficacy scale and Schwarzer's Generalized Self-Efficacy scale); offline and online social self-efficacy (Self-Efficacy Questionnaire for Children and Self-Efficacy scale); academic, social, physical appearance, athletic, and behavioural self-concept (Harter's Self-Competence scale, Rosenberg's Self-Esteem scale, Marsh's Physical Self-Description questionnaire). All measures were assessed through a self-reported questionnaire. Some studies modified the scales.								
10 Cross-ectionall[a] n = 82,919	Serious risk of bias[b]	Serious inconsistency [c]	No serious indirectness	No serious imprecision	Exposure /Outcome Gradient [d]	Stanczykiewicz et al. 2019 *(27)* (k=8; n = NR)[h]: **5/8 studies** found statistically significant association between SB and anxiety symptoms, although results were inconsistent across measures of SB within studies. Overall, the estimated average effect was not statistically significant (*r* = 0.05 [95% CI, -0.01 to 0.11], p = 0.085). Higher sedentary behavior was associated with lower self-esteem for: 1) Accelerometer-derived sedentary time – *0/2 studies.* 2) Accelerometer-derived sedentary bouts – *0/1 study.* 3) Accelerometer-derived sedentary breaks – *0/1 study.* 4) Screen time – *2/2 studies* (not physical self-concept in 1 study). 5) TV – *2/4 studies.* 6) Computer – *3/5 studies* (one for females only in 1 study, not for online game in 1 study, not for physical concept in 1 study. 7) Video games – *¼ studies* (only in self-concept and self-esteem in 1 study). Higher sedentary behavior was associated with higher self-esteem for: 1) Computer – *1/5 studies* (only for self-concept in 1 study) 2) Video games – *¼ studies* (only for online self-efficacy for 1 study)	VERY LOW[e]	Outcome not included

						3) cell phone – *2/2 studies* (not for global self-esteem in 1 study and only for social self-concept in 1 study).		
1 Longitudinal[f] n = 519	Serious risk of bias	Unable to assess	No serious indirectness	No serious imprecision	None	In boys, higher sedentary behaviour is associated with lower self-esteem (0/1) 1) Other Screen time (computers, video game consoles mobile devices) (1/1) 2) TV (0/1) In girls, higher sedentary behavior was associated with higher self-esteem. 1) Other Screen time (computers, video game consoles mobile devices) (0/1) 2) TV (1/1)	VERY LOW[i]	
Psychological distress								
Mean age ranged between 13.54 and 18.43 years; where mean age was not reported, age ranged from 6 to 15 years. Data were collected by longitudinal design (n=6). Psychological Distress was assessed using different methods. Anxiety was assessed using the Self-Rating Anxiety Scale (SAS). Depression was assessed using the Center for Epidemiologic Studies Depression Scale (CES-D) and the Mood and Feelings Questionnaire (MFQ). Psychopathological symptoms were measured using the Multidimensional Sub-health Questionnaire of Adolescents (MSQA). Psychopathological symptoms were measured using the Multidimensional Sub-health Questionnaire of Adolescents (MSQA).								
6 Longitudinal[g] n = 7,417	Serious risk of bias	No serious inconsistency	No serious indirectness	No serious imprecision	None	Higher sedentary behavior associated with higher levels of psychological distress 1) Accelerometer-derived sedentary time – 0/2 studies 2) Screen time – 4/4 studies 3) Computer use for homework – 0/1 study 4) TV – 0/1 study	LOW[j]	

[*]As determined by WHO

[a]Includes 10 cross-sectional studies *(127, 214, 225-232)*.

[b]Of the nine studies that used a subjective measure of sedentary behaviour, only one study *(231)* reported psychometric properties for the items.

[c]Mixed findings were observed.

[d]A gradient for higher screen time and TV with lower self-esteem was observed in 3 studies *(214, 230, 232)*.

[e] The quality of evidence for cross-sectional studies was downgraded to “very low” from “low” due to serious risk of bias and serious inconsistent

[f] Includes one longitudinal study (Braig et al. 2018).

[g] Includes 6 longitudinal studies (Sund et al. 2011; Hume et al. 2011; Gunnell et al. 2016; Wu et al. 2016; Zahl et al. 2017; Babic et al. 2017).

[h] Review included studies among children, adolescents, and adults. Only 8 of 31 total included studies were among children or adolescents.

[i]The quality of evidence for the longitudinal study could not be upgraded from “low” to “moderate” due to serious risk of bias and was downgraded from “low” to “very low” due to inability to assess consistency (1 study).

[j]The quality of evidence for the longitudinal studies could not be upgraded from “low” to “moderate” due to serious risk of bias.

Table A.2.g. Cognitive outcomes and sedentary behavior, children and adolescents

Questions: What is the association between **sedentary behaviour** and health-related outcomes? Is there a dose response association (total volume and the frequency, duration and intensity of interruption)? Does the association vary by type and domain of sedentary behaviour?
Population: Children aged 5-under 18 years of age
Exposure: Greater volume, decreased frequency, duration or intensity of interruption of sedentary behaviour
Comparison: Lesser volume, increased frequency, duration or intensity of interruption of sedentary behaviour
Outcome: Cognitive outcomes (e.g., academic performance, executive function)
***Importance**: CRITCAL

Black font is from original GRADE Evidence Profiles for academic achievement from Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (12-17 years).*(6)*
Red font denotes additions based on WHO update using review of existing systematic reviews.

	Quality Assessment							
No. of studies/ Study design **No. of participants**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other**	**Summary of findings**	**Certainty**	**US PAGAC evidence and conclusions** ***(30)***
Mean baseline age ranged between 12.0 and 16.9 years; where mean age was not reported, baseline age ranged from 6 to 18 years and grades 9 to 12. Data were collected by longitudinal (n=4) and cross-sectional (n=12) study designs with up to 2 years follow up. Academic achievement was assessed as school/academic performance (self- and proxy-report by interview, questionnaire and Child Behaviour Checklist); grades/grade point average (self- and proxy-report by interview or questionnaire, objectively measured) standardized test scores (National Center for Education Statistics, the National Assessment Program for Literacy and Numeracy); and Reading and Mathematics skills (Wide Range Achievement Test, Revision 3).								
10 Longitudinal[a] n = 33,703 **No eligible reviews identified.**	Serious risk of bias[b]	Serious inconsistency	No serious indirectness	No serious imprecision	Dose response gradient[c]	Among *longitudinal findings*, higher sedentary behaviour was associated with lower academic achievement for: 1) Total screen time – 2/2 studies 2) TV - *3/6 studies* (weekdays only for one study). 3) Video games - *2/6 studies*. 4) Computer - *1/2 study.* 5) Non-school sedentary time excluding TV – 1/1 studies 6) Mobile Phone – 0/1 study Among longitudinal findings, higher sedentary behaviour was associated with higher academic achievement for: - Accelerometer – derived sedentary time – 2/2 studies 1) Reading - *2/3 studies*. 2) Homework outside of school *-2/2 study.*	LOW[d]	Outcome not included
12 Cross-sectional[e] n = 14,887	Serious risk of bias[f]	Serious inconsistency	No serious indirectness	No serious imprecision	Exposure /outcome gradient[h]	Higher sedentary behaviour was associated with lower academic achievement for: 1) TV - *1/6 studies* (only for males in 1 study). 2) Video games - *3/6 studies (for GPA only in 1 study).* 3) Computer - *1/4 study.* 4) Total sedentary behaviour - 1/2 studies 5) Cell phone - *0/2 studies*	VERY LOW[i]	

No eligible reviews identified.						Higher sedentary behaviour was associated with higher academic achievement for: 1) Computer - *1/4 studies*. 2) Total sedentary behaviour - *1/2 studies* (before school only for 1 study). Due to heterogeneity in the measurement of sedentary behaviour and academic achievement a meta-analysis was not possible.		

[*]As determined by WHO
[a]Includes ~~4~~ 10 longitudinal studies *(233-236)*.
[b]No studies provided information on psychometric properties of the sedentary behaviour items.
[c]A dose-response gradient for higher TV/accelerometer derived sedentary time and lower academic achievement or reading and homework with higher academic achievement was observed in ~~2~~ 4 studies *(233, 235)*; Aggio et al. 2016; Wickel et al. 2017).
[d]The quality of evidence for longitudinal studies could not be upgraded from “low” to “moderate” due to serious risk of bias and was downgraded to “very low” from “low” due to serious inconsistency but upgraded to “low” from “very low” due to a dose response gradient.
[e]Includes 12 cross-sectional study *(226, 228, 237-246)*.
[f]Apart from 3 studies *(238, 242, 244)* information on psychometric properties of the sedentary behaviour items were not provided.
[g]Mixed findings were observed.
[h]A gradient for higher video games and computer use with lower academic achievement was observed in 2 studies *(226, 241)*.
[i]The quality of evidence for cross-sectional studies was downgraded to “very low” from “low” due to serious risk of bias and serious inconsistency.

Table A.2.h. Prosocial behavior and sedentary behavior, children and adolescents

Questions: What is the association between **sedentary behaviour** and health-related outcomes? Is there a dose response association (total volume and the frequency, duration and intensity of interruption)? Does the association vary by type and domain of sedentary behaviour?
Population: Children aged 5-under 18 years of age
Exposure: Greater volume, decreased frequency, duration or intensity of interruption of sedentary behaviour
Comparison: Lesser volume, increased frequency, duration or intensity of interruption of sedentary behaviour
Outcome: Prosocial behaviour (e.g., conduct problems, peer relations, social inclusion)
***Importance**: IMPORTANT

Black font is from original GRADE Evidence Profiles from Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (12-17 years).*(6)* Red font denotes additions based on WHO update using review of existing systematic reviews.

	Quality Assessment							
No. of studies/ Study design **No. of participants**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other**	**Summary of findings**	**Certainty**	**US PAGAC evidence and conclusions** *(30)*
Mean baseline age ranged between 5 and 14 years; where mean age was not reported, baseline age ranged from 4 to 18 years and grades 6 to 10. One study did not report age or grade, rather that the sample was male guidance school students. Data were collected by randomized controlled trial (n=1), cross-over trial (n=1), longitudinal (n=10), and cross-sectional (n=12) study designs with up to 21 years follow up. Behavioural conduct/pro-social behaviour was assessed as ADHD symptoms (parent- and teacher-reported ADHD-IV Rating Scale, parental reported Strengths and Difficulties Questionnaire), time on task (direct observation), conduct problems (parent-reported Strength and Difficulties Questionnaire), peer relationship problems (parental-reported Strength and Difficulties Questionnaire), pro-social behaviour (parental-reported Strengths and Difficulties Questionnaire), criminal conviction (computer system), antisocial personality (modified Diagnostic Interview Schedule, self-reported Negative Life Events instrument), personality traits (self-reported Multidimensional Personality Questionnaire), behavioural problems (parental-reported Behavioural Problems Index, parental-reported 11-item symptomology checklist, self-reported Achenbach's Youth Questionnaire), aggression/violence (teacher-reported, self-report questionnaire, self-reported Buss and Perry's Aggression Questionnaire, parental-reported Child Behavior Checklist, self-reported State-Trait Anger and the Anger Expression Scale), attention/inattention/hyperactivity problems (teacher-reported questionnaire, self- and parental-reported Child Behavior Checklist, parental-reported Strength and Difficulties Questionnaire, self-reported ADHD symptoms scale, parental-reported ADHD Rating Scale-IV and parent and child attention symptomology checklist), impulsiveness (self-reported Barratt Impulsiveness Scale - II), serious and covert conduct (self-report questionnaire), bullying perpetration (self-reported Kidscape Questionnaire), social problem/withdrawn/delinquent behaviour (parental reported Child Behavior Checklist).								
1 Randomized controlled Trial[a] n = 202 **No eligible reviews identified.**	No serious risk of bias	Unable to assess	Serious indirectness[b]	No serious imprecision	None	Smaller decrease in unfavourable measures of behavioural conduct/pro-social behaviour for the sedentary art group compared to the physical activity group for: 1) Non-Screen time - *1/1 study* (not for parental- or teacher-reported hyperactivity/impulsivity, oppositional behaviour, moodiness, behaviour toward peers, and reputation with peers and not for teacher-reported inattention).	LOW[c]	Outcome not included
1 Cross-over Trial[d] n = 96	No serious risk of bias	Unable to assess	No serious indirectness	No serious imprecision	None	Unfavourable measures of behavioural conduct/pro-social behaviour for the sedentary group compared to the physical activity group for: 1) Non-Screen time - *1/1 study* (only for 10-minute exercise break group).	VERY LOW[e]	

No eligible reviews identified.								
14 Longitudinal[f] n = 43,784 **No eligible reviews identified.**	Serious risk of bias[g]	No serious inconsistency	No serious indirectness	No serious imprecision	Dose-response gradient[h]	For *longitudinal findings*, higher sedentary behaviour was associated with unfavourable measures of behavioural conduct/pro-social behaviour for: 1) Screen time – *4/4 studies* (not for emotional symptoms, hyperactivity/inattention, peer relationship problems or pro-social behaviour in 1 study). 2) TV - *5/6 studies* (not for violent conviction by age 26yr in 1 study, not for emotional symptoms, hyperactivity/ inattention, peer relationship problems, or pro-social behaviour for 1 study, only in females for 1 study). 3) Video games - *6/9 studies* (not for serious or covert conduct problems in 1 study). For longitudinal findings, higher sedentary behaviour was associated with favourable measures of behavioural conduct/pro-social behaviour for: 1) Computer - *1/2 studies* (only in females for 1 study).	LOW[i]	
12 Cross-sectional[j] n = 95,287 **No eligible reviews identified.**	Serious risk of bias[k]	No serious inconsistency	No serious indirectness	No serious imprecision	None	Higher sedentary behaviour was associated with unfavourable measures of behavioural conduct/pro-social behaviour for: 1) Screen time - *1/3 studies*. 2) TV - *4/6 studies* (not for withdrawn in 1 study, not for parental-reported attention problems, or antisocial personality in 1 study). 3) Computer - *3/5 studies* (not for anger in and anger control in 1 study). 4) Video game - *3/4 studies* (not for behavioural problems or attention problems in 4 to 8 and 13 to 18 yr olds in 1 study, not for parental-reported attention problems, or antisocial personality in 1 study). 5) Higher tech time - *1/1 study each* (not for behavioural problems in 4 to 8 yr olds or attention and behavioural problems for 9 to 12 yr olds).	VERY LOW[l]	

Abbreviations: ADHD = attention deficit/hyperactivity disorder; TV = television viewing.

[*]As determined by WHO
[a]Includes 1 randomized controlled trial *(247)*.
[b]It is unclear if children were engaging in sedentary time during the whole before school period and whether the art class was just replacing other sedentary time.
[c]The quality of evidence for the randomized controlled trial was downgraded to "low" from "high" due to serious indirectness and inability to assess inconsistency (1 study).
[d]Includes 1 cross-over trial *(248)*.
[e]The quality of evidence for the cross-over trial was downgraded to "very low" from "low" due to inability to assess consistency (1 study).
[f]Includes 14 longitudinal studies *(81, 234, 249-256)*; Allen et al. 2015; Roser et al. 2016; Chaelin et al. 2018; Wu et al. 2018).
[g]Apart from 2 studies *(249, 251)* information on psychometric properties of the sedentary behaviour items were not provided.
[h]A dose-response gradient was for higher TV, screen time, computer, and video games with unfavourable behavioural conduct/pro-social behaviour was observed in ~~6~~9 studies *(234, 251-255)*; Allen et al. 2015; Wu et al. 2018; Chaeli et al. 2018).
[i] The quality of evidence for the longitudinal studies was not upgraded from "low" to "moderate" due to serious risk of bias but was upgraded to "moderate" from "low" for dose-response gradient.
[i]Includes 12 cross-sectional studies *(43, 127, 238, 242, 257-264)*.
[j]Apart from 4 studies *(43, 238, 242, 262)* information on psychometric properties of the sedentary behaviour items were not provided.
[k]Two studies used the German Health Interview and Examination Survey for Children and Adolescents *(43, 264)*.
[l] The quality of evidence for cross-sectional studies was downgraded to "very low" from "low" due to serious risk of bias.

Table A.2.i. Sleep duration and quality and sedentary behavior, children and adolescents

Questions: What is the association between **sedentary behaviour** and health-related outcomes? Is there a dose response association (total volume and the frequency, duration and intensity of interruption)? Does the association vary by type and domain of sedentary behaviour?
Population: Children aged 5-under 18 years of age
Exposure: Greater volume, decreased frequency, duration or intensity of interruption of sedentary behaviour
Comparison: Lesser volume, increased frequency, duration or intensity of interruption of sedentary behaviour
Outcome: Sleep duration and quality
*__Importance__: IMPORTANT

No GRADE Evidence Profiles from Australian 24-Hour Movement Guidelines for Children (5-12 years) and Young People (12-17 years)*(6)* and no systematic reviews identified by WHO.

	Quality Assessment							
No. of studies/ Study design **No. of participants**	**Risk of bias**	**Inconsistency**	**Indirectness**	**Imprecision**	**Other**	**Summary of findings**	**Certainty**	**US PAGAC evidence and conclusions** *(30)*
8 Longitudinal studies n = NR	Serious risk of bias[a]	No serious inconsistency	Serious indirectness[b]	Could not be determined[c]	None	Belmon et al. 2019 *(10)* (45 longitudinal studies; n=NR)[d]: **4/4 studies** found that more screen time was associated with shorter sleep duration and **5/5 studies** found that more TV watching was associated with shorter sleep duration. **2/2 studies** reported no association between computer use/gaming and sleep duration. **1/1 study** found no association between screen time and sleep quality or sleep timing.	VERY LOW[e]	Outcome not included

Abbreviations: NR = not reported; SB = sedentary behavior; TV = television

[*]As determined by WHO
[a] Serious risk of bias. All included studies were rated as low quality.
[b] Serious indirectness. Measures of SB were limited to screen time and TV watching
[c] Precision unable to be determined based on data reported in review.
[d] Review included 45 total studies examining the correlates of sleep behavior in children and adolescents. 8/45 studies examined the association between SB and sleep.
[e] The quality of evidence from longitudinal studies was not upgraded from “low” to “moderate” due to serious risk of bias and was downgraded to “very low” from “low” due to serious indirectness and inability to determine imprecision.

Appendix 1A. Data Extractions

SR/MA **Citation:** Bea JW, Blew RM et al. Resistance training effects on metabolic function among youth: A systematic review. *Ped Exerc Sci* 2017;29(3):297-315.	
Purpose: To evaluate the relationship between resistance training and metabolic function in youth. **Timeframe:** Inception - 2015 **Total # studies included:** 13 **Other details** Evidence was from randomized trials only. **Outcomes addressed:** Cardiometabolic health: metabolic syndrome, insulin resistance, or any component of their definitions	**Abstract:** **Purpose:** This systematic review evaluates the relationship between resistance training and metabolic function in youth. **Methods:** PubMed, Embase, Cochrane Library, Web of Science, CINAHL, and ClinicalTrials.gov were searched for articles that: (1) studied children; (2) included resistance training; (3) were randomized interventions; and (4) reported markers of metabolic function. The selected studies were analyzed using the Cochrane Risk-of-Bias Tool. **Results:** Thirteen articles met inclusion criteria. Mean age ranged from 12.2–16.9 years, but most were limited to high school (N=11) and overweight/obese (N=12). Sample sizes (N= 22–304), session duration (40–60min), and intervention length (8–52 wks) varied. Exercise frequency was typically 2–3 d/wk. Resistance training was metabolically beneficial compared to control or resistance plus aerobic training in 5 studies overall and 3 out of the 4 studies with the fewest threats to bias ($P \leq 0.05$); each was accompanied by beneficial changes in body composition, but only one study adjusted for change in body composition. **Conclusions:** Limited evidence suggests that resistance training may positively affect metabolic parameters in youth. Well-controlled resistance training interventions of varying doses are needed to definitively determine whether resistance training can mitigate metabolic dysfunction in youth and whether training benefits on metabolic parameters are independent of body composition changes.

SR/MA: Systematic review **Citation:** Belmon LS, van Stralen MM, Busch V, Harmsen IA, Chinapaw MJM. What are the determinants of children's sleep behaviour? A systematic review of longitudinal studies. Sleep Medicine Reviews 2019;43:60-70.	
Purpose: Review the longitudinal evidence on determinants of children's sleep behaviour	**Abstract:** **BACKGROUND:** Aim of the review is to systematically review the longitudinal evidence on determinants of children's sleep behaviour. **DATA SOURCES:** Systematic search of PubMed, PsychInfo and Web of Science for papers published until January 2017 with additional hand searching of papers found in reference lists. **STUDY SELECTION**: Papers were required to have a longitudinal design and include potential determinants of sleep behaviour (duration, quality and timing) and include participants aged 4-12 years of age. Papers had to be published in English. **DATA EXTRACTION**: Two independent reviewers screened all titles and abstracts. Full papers were extracted by one researcher and checked by another with discrepancies resolved by consensus. Study quality was assed using a 13-item scale devised by one of the authors. Data for each question of interest were combined to provide an overall assessment of the quality of evidence, which was interpreted as strong, moderate or insufficient to draw conclusions. **DATA SYNTHESIS:** Forty-five studies were identified and of these 12 were classed as "high quality". The team found strong evidence for child age being associated with sleep duration. There was moderate strength evidence for an association between screen-time, past sleep behaviour and a difficult temperament being potential determinants of sleep duration. There was moderate evidence for a negative association between weekend schedule and sleep timing. There was insufficient evidence for the determinants of sleep quality. **LIMITATIONS**: Study limited to healthy children. Cannot assess causation in samples. **CONCLUSIONS:** Age associated with sleep duration and some evidence that screen-time, past sleep duration and temperament associated with sleep duration. There was a lack of high quality evidence to fully assess the key research questions suggesting that more evidence is needed in this area.
Timeframe: Papers published up to Jan 2017.	
Total # studies included: 45	
Other details: The relevance of the review to the research question is unclear as it focusses on the determinants of sleep behaviours not the associations between sleep behaviour and health outcomes or health outcomes and physical activity.	
Outcomes addressed: Sleep duration, sleep quality and sleep timing.	

<table>
<tr><td colspan="2">SR/MA
Citation: Cao M, Quan M, Zhuang J. Effect of high-intensity interval training versus moderate-intensity continuous training on cardiorespiratory fitness in children and adolescents: a meta-analysis. Int J Environ Res Public Health 2019;16:1533.</td></tr>
<tr><td>Purpose: To compare the effects between high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) on cardiorespiratory fitness in children and adolescents.</td><td rowspan="5">Abstract:
Enhancing cardiorespiratory fitness (CRF) can lead to substantial health benefits. Comparisons between high-intensity interval training (HIIT) and moderate-intensity continuous training (MICT) on CRF for children and adolescents are inconsistent and inconclusive. The objective of this study
was to perform a meta-analysis to compare the effects between HIIT and MICT on CRF in children and adolescents. We searched MEDLINE, PubMed, Web of Science, and Google Scholar to identify relevant articles. The standardized mean differences (SMD) and 95% confidence intervals (95% CI)
were calculated to determine the pooled effect size of HIIT and MICT on CRF. A total of 563 subjects from 17 studies (18 effects) were identified. The pooled effect size was 0.51 (95% CI = 0.33–0.69) comparing HIIT to MICT. Moreover, intervention duration, exercise modality, work and rest ratio,
and total bouts did not significantly modify the effect of HIIT on CRF. It is concluded that compared with endurance training, HIIT has greater improvements on cardiorespiratory fitness among children and adolescents.</td></tr>
<tr><td>Timeframe: Inception – February 2019</td></tr>
<tr><td>Total # studies included: 17</td></tr>
<tr><td>Other details: RCTs or controlled trials only.</td></tr>
<tr><td>Outcomes addressed: Cardiorespiratory fitness</td></tr>
</table>

<table>
<tr><td colspan="2">SR/MA
Citation: Collins H, Fawker S et al. The effect of resistance training interventions on weight status in youth: a meta-analysis. Sports Medicine Open 2018;4:41.</td></tr>
<tr><td>Purpose: To examine the effect of resistance training interventions on weight status in youth.</td><td rowspan="5">Abstract:
Background: There has been a rise in research into obesity prevention and treatment programmes in youth, including the effectiveness of resistance-based exercise. The purpose of this meta-analysis was to examine the effect of resistance training interventions on weight status in youth.
Methods: Meta-analysis followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines and was registered on PROSPERO (registration number CRD42016038365). Eligible studies were from English language peer-reviewed published articles. Searches were conducted in seven databases between May 2016 and June 2017. Studies were included that examined the effect of resistance training on weight status in youth, with participants of school age (5–18 years).
Results: There were 24 complete sets of data from 18 controlled trials (CTs) which explored 8 outcomes related to weight status. Significant, small effect sizes were identified for body fat% (Hedges' g = 0.215, 95% CI 0.059 to 0.371, P = 0.007) and skinfolds (Hedges' g = 0.274, 95% CI 0.066 to 0.483, P = 0.01). Effect sizes were not significant for: body mass (Hedges' g = 0.043, 95% CI − 0.103 to 0.189, P = 0.564), body mass index (Hedges' g = 0.024, 95% CI − 0.205 to 0.253, P = 0.838), fat-free mass (Hedges' g = 0.073, 95% CI − 0.169 to 0.316, P = 0.554), fat mass (Hedges' g = 0.180, 95% CI − 0.090 to 0.451, P = 0.192), lean mass (Hedges' g = 0.089, 95% CI − 0.122 to 0.301, P = 0.408) or waist circumference (Hedges' g = 0.209, 95% CI − 0.075 to 0.494, P = 0.149).
Conclusions: The results of this meta-analysis suggest that an isolated resistance training intervention may have an effect on weight status in youth. Overall, more quality research should be undertaken to investigate the impact of resistance training in youth as it could have a role to play in the treatment and prevention of obesity.</td></tr>
<tr><td>Timeframe: Inception - June 2017</td></tr>
<tr><td>Total # studies included: 18 (24 datasets)</td></tr>
<tr><td>Other details Evidence was from controlled trials only.</td></tr>
<tr><td>Outcomes addressed: Adiposity and weight status</td></tr>
</table>

<table>
<tr><td colspan="2">SR/MA
Citation: Eddolls WT, McNarry MA, Stratton G, Winn CO, Mackintosh KA. High-intensity interval training interventions in children and adolescents: A systematic review. Sports Medicine. 2017; 1;47(11):2363-74.</td></tr>
<tr><td>Purpose: Assess impact of HIIT interventions on health outcomes in young people

Timeframe: Inception to 09/2016

Total # studies included: 13

Other details (e.g. definitions used, exclusions etc): Only healthy (non-clinical) samples, and only interventional (not observational) research.

Outcomes addressed: All were eligible. However, results only found CVD outcomes; including BMI, Blood Pressure and various biomarkers of cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, blood triglycerides, and insulin.</td>
<td>Abstract:
Background: Whilst there is increasing interest in the efficacy of high-intensity interval training in children and adolescents as a time-effective method of eliciting health benefits, there remains little consensus within the literature regarding the most effective means for delivering a high-intensity interval training intervention. Given the global health issues surrounding childhood obesity and associated health implications, the identification of effective intervention strategies is imperative.
Objectives: The aim of this review was to examine high-intensity interval training as a means of influencing key health parameters and to elucidate the most effective high- intensity interval training protocol.
Methods: Studies were included if they: (1) studied healthy children and/or adolescents (aged 5–18 years); (2) prescribed an intervention that was deemed high intensity; and (3) reported health-related outcome measures.
Results: A total of 2092 studies were initially retrieved from four databases. Studies that were deemed to meet the criteria were downloaded in their entirety and independently assessed for relevance by two authors using the pre-determined criteria. From this, 13 studies were deemed suitable. This review found that high-intensity interval training in children and adolescents is a time-effective method of improving cardiovascular disease biomarkers, but evidence regarding other health-related measures is more equivocal. Running-based sessions, at an intensity of 90% heart rate maximum/100–130% maximal aerobic velocity, two to three times a week and with a minimum intervention duration of 7 weeks, elicit the greatest improvements in participant health.
Conclusion: While high-intensity interval training improves cardiovascular disease biomarkers, and the evidence supports the effectiveness of running-based sessions, as outlined above, further recommendations as to optimal exercise duration and rest intervals remain ambiguous owing to the paucity of literature and the methodological limitations of studies presently available.</td></tr>
</table>

Systematic Review **Citation:** Errisuriz VL, Golaszewski NM, Born K, Bartholomew JB. Systematic Review of Physical Education-Based Physical Activity Interventions Among Elementary School Children. J Prim Prev 2018;39(3):303–27.	
Purpose: To systematically review studies examining PE interventions designed to impact PA, fitness, and/or body composition; and to make recommendations for new research directions based upon these findings. **Timeframe:** Not reported. **Total # studies included:** 12 **Author-stated inclusion criteria:** The study must have tested an intervention (i.e., a deliberate attempt to change usual teaching practice in PE) with the intention of increasing PA or fitness. Only studies utilizing experimental or quasi-experimental methods. Only elementary (or primary) schools. **Outcomes addressed:** Physical activity, physical fitness and body composition	**Abstract:** Physical education (PE)-based interventions are a popular method to target children's physical activity (PA) and fitness; however, little is known about their effectiveness or what factors lead to successful interventions. This paper: (1) systematically reviews studies examining PE interventions designed to impact PA, fitness, and/or body composition; and (2) makes recommendations for new research directions based upon these findings. Our systematic review was limited to experimental and quasi-experimental studies conducted in elementary schools. We conducted literature searches using predetermined keywords in 3 databases, identified a total of 4964 potentially relevant studies, and screened their abstracts and full texts for eligibility. This resulted in 12 relevant studies. We used criteria established by Downs and Black (1998) to assess each study's methodological quality. PE interventions consistently showed increases in moderate-to-vigorous PA or vigorous PA during PE class but were less consistent in impacting leisure-time PA. PE interventions affected body composition differentially, depending on the assessment used (i.e., body mass index or skinfold thickness). Half of the studies assessing fitness did not show a significant impact; however, those that did were designed to influence fitness outcomes. Few studies assessed psychosocial determinants regarding PA, and no study demonstrated significant impacts on constructs other than knowledge. Interventions often contained multiple components (e.g., diet, family) implemented alongside PE interventions. Identifying effective intervention components was difficult due to lack of process evaluation. We identify the need for future research to use more objective and accurate PA measurements and adiposity, incorporate measurement of psychological constructs, expand interventions' theoretical basis, and include strong process evaluation.
Populations analysed: Children, adolescents and young adults	**Author-stated funding source:** No funding source used.

<table>
<tr><td colspan="2">SR/MA
Citation: Fang K, Mu M et al. Screen time and childhood overweight/obesity: A systematic review and meta-analysis. Child Care Health Dev. 2019;45:744-753.</td></tr>
<tr><td>Purpose: To estimate the relationship between screen time and overweight/obesity in children.</td><td rowspan="5">Abstract:
Background: Controlling childhood overweight/obesity would help early prevention on children from getting chronic noncommunicable diseases, exposing to screen for long periods may increase the risk of overweight/obesity due to lack of physical activity and tend to intake too much energy, and the relationship between screen time and overweight/obesity is inconsistent. Thus, the object of the present study was to estimate the relationship between screen time and overweight/obesity in children (<18 years) by systematically review prevalence studies.
Methods: We collected data from relevant studies published up to May 2019 using predefined inclusion/exclusion criteria. And all the literatures were searched in PubMed, ScienceDirect, Embase, and Web of Science.
Results: A total of 16 studies met the criteria and were included in the meta-analysis. When compared with the screen time <2 hr/day, an increased overweight/obesity risk among children was shown in the screen time ≥2 hr/day (OR = 1.67; 95% CI [1.48, 1.88], P < .0001). The subgroup analysis showed a positive association between the different types of screen time and overweight/obesity among children.
Conclusion: Based on our study, increasing screen time could be a risk factor for being overweight/obesity in children and adolescents.</td></tr>
<tr><td>Timeframe: Inception – May 2019</td></tr>
<tr><td>Total # studies included: 16</td></tr>
<tr><td>Other details: Evidence from cohort study, case–control or cross-sectional study designs. Screen time was categorized as <2 and ≥2 hr/day.</td></tr>
<tr><td>Outcomes addressed: adiposity (overweight/obesity)</td></tr>
</table>

SR/MA **Citation:** Koedijk JB, Rijswijk et al. Sedentary behaviour and bone health in children, adolescents and young adults: a systematic review. *Osteoporos Int* 2017;28:2507-2519.	
Purpose: To examine the association between SB and bone health in children, adolescents and young adults. **Timeframe:** Inception – Jan. 2019 **Total # studies included:** 17 **Other details** There were no restrictions placed on study design. **Outcomes addressed:** Bone health	**Abstract:** Sedentary behaviour (SB) is increasing in Western societies and some studies suggest a deleterious effect of SB on bone. The aim of this systematic review was to examine the association between SB and bone health in children, adolescents and young adults. Electronic databases (PubMed, MEDLINE, PsycINFO and Science Citation Index) were searched for relevant articles up to January 9, 2017. Studies were included when results on bone health (e.g. strength, mass and structure) and either subjectively (questionnaires) or objectively (accelerometry) measured SB were reported in healthy participants ≤24 years. Two reviewers independently screened titles and abstracts for eligibility, rated methodological quality and extracted data. Seventeen observational studies were included. Several studies that used DXA or quantitative ultrasound suggested that objectively measured SB was negatively associated with lower extremity bone outcomes, such as femoral neck bone mineral density. The magnitude of this negative association was small and independent of moderate-to-vigorous physical activity. In contrast to the lower extremities, there was insufficient evidence for an association of lumbar spine bone outcomes with objectively measured SB. In high-quality studies that used DXA, no association was observed between objectively measured SB and total body bone outcomes. In studies using questionnaires, none of these relationships were observed. Well-designed longitudinal studies, objectively measuring SB, are needed to further unravel the effect of SB, physical activity and their interaction on bone health.

<table>
<tr><td colspan="2">SR/MA
Citation: Krahenbühl T, Guimarães RF et al. Bone geometry and physical activity in children and adolescents: systematic review. Rev Paul Pediatr. 2018;36(2):230-237.</td></tr>
<tr><td>Purpose: To examine the influence of physical activity and/or sports on bone geometry in children and adolescents.</td><td rowspan="5">Abstract:
Objective: To perform a systematic review on the practice of physical activity and/or sports in health and its influence on bone geometry of healthy children and adolescents.
Data source: The method used as reference was the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA). Databases searched for articles published from 2006 to 2016, with “Bone geometry” AND (Sport* OR Exercise* OR “Physical Activity”) as descriptors, were PubMed, BIREME/LILACS and SciELO.
Data syntheses: After the selection, 21 articles were included. Most studies stated that practice of physical activity and/or sports was beneficial for bone geometry and bone mineral density. Only two studies presented values of bone parameters for control individuals better than those of swimmers. Physical activities and sports studied were: gymnastics (n=7), rhythmic gymnastics (n=2), tennis (n=1), soccer (n=3), capoeira (n=1), swimming (n=4), cycling (n=0), jumping activities (n=2), studies relating physical activity with isokinetic peak torque (n=1), physical activity measured by questionnaire (n=4), and additional physical education classes (n=2).
Conclusions: Among the sports and physical activities found, gymnastics, soccer, and more intense physical activity assessed by questionnaires were mentioned along with better results in bone geometry compared to the absence of physical activity, whereas swimming and jumping exercises did not influence it. Therefore, sports activities with weight bearing and those
practiced more frequently and intensively are beneficial for bone geometry.</td></tr>
<tr><td>Timeframe: 2006 until 2016</td></tr>
<tr><td>Total # studies included: 21</td></tr>
<tr><td>Other details: Evidence from observational studies only (13 cross-sectional and 8 longitudinal studies).</td></tr>
<tr><td>Outcomes addressed: Bone geometry</td></tr>
</table>

SR/MA: Systematic review **Citation:** Lee, Pope and Gao. The role of Youth Sports in promoting children's physical activity and preventing pediatric obesity: A systematic review. Behavioural Medicine 2018;44(1):62-76.	
Purpose: Examine the impact of youth sports participation on daily physical activity and paediatric obesity in children aged 6 to 19. **Timeframe:** Up to Jan 2014 **Total # studies included:** 27 **Other details** Majority of the studies used single item assessments of sports participation. Limited information about frequency, intensity etc. It is a narrative synthesis and no pooling of data across studies. Although study quality is assessed the link between study quality and interpretation is unclear. **Outcomes addressed:** Physical activity (MVPA) and obesity status which was defined as BMI, body fat percentage, and waist circumference**.**	**Abstract:** **BACKGROUND:** Aim of the paper was to examine the impact of youth sports participation on daily physical activity and pediatric obesity in children aged 6 to 19. **DATA SOURCES:** English-language studies in Web of Science, Academic Search Premier, Google Scholar, Pub Med, PsychInfo and ERIC were searched for studies published up to January 2014 with additional hand searching of papers found in reference lists. **STUDY SELECTION**: Studies had to include children <19 years of age and examine association between sport participation, and physical activity related outcomes [(adherence to PA guidelines, leisure time physical activity, total energy expenditure, time in MVPA and/or obesity related outcomes (BMI, body fat percentage, skinfold and or obesity related outcomes)]. Studies that combined PE with after-school sports and studies targeting participants with disabilities were excluded. **DATA EXTRACTION**: Data extracted by one reviewer and verified by another. Discrepancies resolved by consensus. Quality of study findings and methodology were assessed using a 9-item checklist that had been developed by the team. **DATA SYNTHESIS:** Twenty-seven articles were found with samples ranging from 21 to 71,854. Of the included studied 16 focused on adolescents only. A total of 17 studies examined associated between youth sport and physical activity and of these 15 showed that greater amounts and frequency of engagement in organized youth sport were associated with physical activity in youth or later in adolescence. From the 7 studies, 7 presented odds ratios to quantify the magnitude of the sports participation and PA relationship and these ranged from 17.4 (95% CI = 1.13 to 2.67) to 13.2 (95% CI = 9.4 to 18.7). In the studies that investigated the relationship of school-based sports and physical activity sports-based participants were more likely to engage in MVPA (OR = 3.21 [95% CI = 2.95 to 3.49] than non-participants. Seventeen studies examined the association between youth sports participation and obesity status with sample sizes from 21 to 12,188 and age ranges from 6 to 19 years of age. Evidence for an association between sports participation and obesity were mixed and inconsistent. **LIMITATIONS**: The majority of the studies had self-reported measures of physical activity (only 7 used accelerometers or pedometers). Most of the sport participation surveys used a single item and did not assess frequency, duration or type of participation. **CONCLUSION:** Participating in youth sports is positively associated with MVPA and there is some evidence that these associations persist into later adolescence and adulthood. There is inconsistent evidence of an association between youth sports participation and indicators of obesity related outcomes.

<table>
<tr><td colspan="2">Systematic Review
Citation: Marker C, Gnambs T, Appel M. Exploring the myth of the chubby gamer: A meta-analysis on sedentary video gaming and body mass. Soc Sci Med [Internet]. 2019 Jun 9;(September 2018):112325. Available from: https://doi.org/10.1016/j.socscimed.2019.05.030.</td></tr>
<tr><td>Purpose: To provide an estimate of the average effect size of the relationship between sedentary video gaming and body mass and to provide additional evidence on processes (i.e., displacement effect of physical activity by video gaming time)</td><td rowspan="5">Abstract:
RATIONALE: High body mass and obesity are frequently linked to the use of sedentary media, like television (TV) or non-active video games. Empirical evidence regarding video gaming, however, has been mixed, and theoretical considerations explaining a relationship between general screen time and body mass may not generalize to non-active video gaming.
OBJECTIVE: The current meta-analysis had two main goals. First, we wanted to provide an estimate of the average effect size of the relationship between sedentary video gaming and body mass. In doing so we acknowledged several context variables to gauge the stability of the average effect. Second, to provide additional evidence on processes, we tested the displacement effect of physical activity by video gaming time with the help of a meta-analytic structural equation model (MASEM).
METHOD: Published and unpublished studies were identified through keyword searches in different databases and references in relevant reports were inspected for further studies. We present a random-effects, three-level meta-analysis based on 20 studies (total N = 38,097) with 32 effect sizes.
RESULTS: The analyses revealed a small positive relationship between non-active video game use and body mass, $\hat{\rho}=.09$, 95% CI [0.03, 0.14], indicating that they shared less than 1% in variance. The studies showed significant heterogeneity, Q (31) = 593.03, p < .001, I2 = 95.13. Moderator analyses revealed that the relationship was more pronounced for adults, $\hat{\rho}=.22$, 95% CI [0.04, 0.40], as compared to adolescents, $\hat{\rho}=.01$, 95% CI [-0.21, 0.23], or children, $\hat{\rho}=.09$, 95% CI [-0.07, 0.25]. Meta-analytic structural equation modeling found little evidence for a displacement of physical activity through time spent on video gaming.
CONCLUSION: These results do not corroborate the assumption of a strong link between video gaming and body mass as respective associations are small and primarily observed among adults.</td></tr>
<tr><td>Timeframe: Inception – June 2018</td></tr>
<tr><td>Total # studies included: 24</td></tr>
<tr><td>Author's definition of sedentary video gaming: The authors focus on time and frequency of video gaming only for sedentary (non-active) video games. They exclude studies focused on active video games.</td></tr>
<tr><td>Outcomes addressed: Body mass</td></tr>
<tr><td>Populations analysed: Children, adolescents and young adults</td><td>Author-stated funding source: This work was supported by the German Science Foundation (DFG) Grant AP 207/2-1 awarded to Markus Appel</td></tr>
</table>

<table>
<tr><td colspan="2">SR/MA: Systematic review
Citation: Marques A, Santos DA, Hillman CH, Sardinha LB. How does academic achievement relate to cardiorespiratory fitness, self-reported physical activity and objectively reported physical activity: a systematic review in children and adolescents aged 6-18 years. Br J Sports Med (in press).</td></tr>
<tr><td>Purpose: Review evidence of the association between objective and self-reported physical activity and cardiorespiratory fitness with academic achievement</td><td rowspan="4">Abstract:
BACKGROUND: Aim of the study was to systematically review the evidence from 2000 to 2016 of an association between objective and self-reported physical activity and cardiorespiratory fitness with academic achievement in children and adolescents.
DATA SOURCES: Systematic review of Embase, ERIC, PubMed, PsychINFO, SPORTdiscus and Web of Science. Studies published in English, Spanish or Portuguese were eligible if published from 2000 to 2016.
STUDY SELECTION: Studies had to include children or adolescents aged 6-18, had to have school grade or standardised test as an outcome and assess either self-reported or objectively assessed physical activity or cardiorespiratory fitness. Cross-sectional, longitudinal and intervention (trials) were eligible. Studies with a sample of less than 30 participants were excluded.
DATA EXTRACTION: Titles and abstracts reviewed by two assessors. Full text articles reviewed by same individuals. Discrepancies resolved by consensus. Study quality assessed using the “Quality Assessment Tool for Quantitative Studies”.</td></tr>
<tr><td>Timeframe: 2000 to 2016</td></tr>
<tr><td>Total # studies included: 51</td></tr>
<tr><td>Other details (e.g. definitions used, exclusions etc)
Studies with less than 30 participants excluded. English, Spanish and Portuguese language studies only.</td></tr>
<tr><td>Outcomes addressed:

School grade (teacher assessed) or standardised test score.</td><td>DATA SYNTHESIS: Fifty-one articles were identified and of these 41 were cross-sectional, 8 longitudinal and 2 intervention. In half of the studies the outcome variable was student marks at school and the other was standardised test scores. There were 11 studies that included objective assessments of physical activity and academic achievement. There was inconsistent evidence. There were 18 studies that used self-reported assessments of physical activity and of these 12 reported a positive association between physical activity and academic achievement. The 28 studies that assessed the relationship between cardio-respiratory fitness and academic achievement reported a general positive association with high fitness associated with higher academic achievement (but direction of causation unclear).
LIMITATIONS: Narrative synthesis. Studies were not ranked based on size. Grades from teachers are not standardised and can be open to bias making comparisons across schools challenging.
CONCLUSIONS: Overall findings support a positive association between self-reported physical activity plus cardio-respiratory fitness and academic achievement. Objectively measured physical activity was inconsistently associated with academic achievement. Physical activity DOES NOT have a detrimental effect on academic achievement.</td></tr>
</table>

<table>
<tr><td colspan="2">SR/MA
Citation: Martin R, Murtagh EM. Effect of active lessons on physical activity, academic, and health outcomes: a systematic review. Research Quarterly for Exercise and Sport 2017;88(2):149-68.</td></tr>
<tr><td>Purpose: Examine the benefits of PA interventions integrated within school lessons, for learning, PA and health outcomes</td><td rowspan="5">Abstract:
Purpose: The purpose of this study was to conduct a systematic review of classroom-based physical activity interventions that integrate academic content and assess the effectiveness of the interventions on physical activity, learning, facilitators of learning, and health outcomes.
Method: Six electronic databases (ERIC, PubMed, Google Scholar, Science Direct, Cochrane Library, and EMBASE) and reference lists were searched for English-language articles, published January 1990 through March 2015, reporting classroom-based interventions that deliberately taught academic content using physically active teaching methods for at least 1 week duration, with physical activity, health, learning, or facilitators-of-learning outcomes. Two authors reviewed full-text articles. Data were extracted onto an Excel spreadsheet, and authors were contacted to confirm accuracy of the information presented.
Results: Fifteen studies met the inclusion criteria. Six studies reporting on physical activity levels were found to have medium-to-large effect sizes. All 4 studies reporting learning outcomes showed positive effects of intervention lessons. Teachers and students were pleased with the programs, and enhanced on-task behavior was identified (n = 3). Positive effects were also reported on students' body mass index levels (n = 3).
Conclusions: Physically active academic lessons increase physical activity levels and may benefit learning and health outcomes. Both students and teachers positively received and enjoyed these teaching methods. These findings emphasize the need for such interventions to contribute toward public health policy.</td></tr>
<tr><td>Timeframe: 01/1990 – 03/2015</td></tr>
<tr><td>Total # studies included: 15</td></tr>
<tr><td>Other details (e.g. definitions used, exclusions etc): All classroom-based PA interventions which reported on PA outcomes, health outcomes, or learning-related outcomes.</td></tr>
<tr><td>Outcomes addressed: Physical activity levels, Learning outcomes, Teacher and Student satisfaction with classroom-based PA, and BMI.</td></tr>
</table>

SR/MA **Citation:** Miguel-Berges ML, Reilly JJ et al. Associations between pedometer-determined physical activity and adiposity in children and adolescents: systematic review. *Clin J Sport Med.* 2018;28:64-75.	
Purpose: To examine the evidence on the associations between pedometer-determined physical activity and adiposity.	**Abstract:** **Objective:** The present review sought to examine the evidence on the associations between pedometer-determined physical activity and adiposity. **Design:** Of 304 potentially eligible articles, 36 were included. A search for observational studies was carried out using Cochrane Library (CENTRAL), the OVID (MEDLINE, Embase, and PsycINFO), EBSCOhost (Sportdiscus), and PEDro database from their commencement to July 2015. Of 304 potentially eligible articles, 36 were included. **Results:** Most studies (30/36; 83%) were cross sectional and all used proxies for adiposity, such as body mass index (BMI) or BMI z-score as the outcome measure. Few studies (2/36; 6%) focused on preschool children. There was consistent evidence of negative associations between walking and adiposity; significant negative associations were observed in 72% (26/36) of studies overall. **Conclusions:** The present review supports the hypothesis that higher levels of walking are protective against child and adolescent obesity. However, prospective longitudinal studies are warranted; there is a need for more research on younger children and for more "dose-response" evidence.
Timeframe: Inception – July 2015	
Total # studies included: 36	
Other details: Evidence from observational studies only (83% cross-sectional studies).	
Outcomes addressed: Adiposity	

SR/MA: Systematic review **Citation:** Mohammadi S, Jalaludin MY, Su TT, Dahlui M, Mohamed MNA and Majid HA. Dietary and physical activity patterns related to cardiometabolic health among Malaysian adolescents: a systematic review. BMC Public Health 2019;19:251	
Purpose: Examine the review of the associations in observational and intervention studies of the association between diet, physical activity and cardiometabolic risk factors in Malaysian adolescents. **Timeframe:** Up to August 2017. **Total # studies included:** 17 **Other details (e.g. definitions used, exclusions etc)** The bulk of the review focusses on dietary factors not summarised as out of scope. The sample is limited to studies conducted in Malaysia. Inconsistencies in how results are summarised (i.e. refers to objective measures when it appears ass assessments of physical activity are self-reported). **Outcomes addressed:** BMI and Body weight Although the title talks about cardiometabolic health the outcomes are all indicators of body mass (BMI and body weight).	**Abstract:** **BACKGROUND:** Systematic review of the associations in observational and intervention studies of the association between diet, physical activity and cardiometabolic risk factors in Malaysian adolescents. (As diet is not related to the current research question data have not been abstracted below). **DATA SOURCES:** Systematic search of PubMed, Science Direct, Cochrane Review and Web of Science until 31st August 2017. **STUDY SELECTION**: Observation and intervention studies that included Malaysian adolescents age 13-18. Studies had to include physical activity (including sedentary) or diet as an outcome. **DATA EXTRACTION**: Titles, abstracts and papers were independently screened by two assessors. Disagreements discussed and resolved by two further authors. Risk of bias assessed using a modified Newcastle-Ottawa scale. **DATA SYNTHESIS:** Seventeen studies (16 cross-sectional and one intervention) were found. All 17 studies were classed as poor quality. Physical activity was assessed in ten studies all of which used the Physical Activity Questionnaire for Older children. Seven studies examined the link between physical activity and cardiometabolic health. Three found no evidence of associations. Three studies reported associations between physical activity and weight status, three found associations with BMI, two with percentage of body fat and one with waist circumference. Two studies reported that the mean physical activity score was higher of underweight and normal weight participants when compared to overweight and obese adolescents. There was equivocal evidence of an association between physical activity intensity and cardiometabolic health. Two studies assessed sedentary behaviour. One study reported an association between sedentary time and BMI while the other found no association. **LIMITATIONS**: Self-report measures of physical activity. Poor study quality. **CONCLUSIONS:** Weak evidence of an association between physical activity and indicators of cardiometabolic health (all indicators of adiposity).

<table>
<tr><td colspan="2">SR/MA
Citation: Pozuelo-Carrascosa DP, Cavero-Redondo I, Herraiz-Adillo A et al. School-Based Exercise Programs and Cardiometabolic Risk Factors: A Meta-analysis. Pediatrics. 2018;142(5):e20181033</td></tr>
<tr><td>Purpose: To provide a comprehensive synthesis of the effectiveness of school-based PA interventions on cardiometabolic risk factors in children</td><td rowspan="5">Abstract:
CONTEXT: The effects of school-based physical activity (PA) programs on different cardiometabolic risk factors and the most appropriate features of PA programs to achieve maximum effectiveness are unclear.
OBJECTIVE: To provide a comprehensive synthesis of the effectiveness of school-based PA interventions on cardiometabolic risk factors in children.
DATA SOURCES: We identified studies from database inception to February 22, 2018.
STUDY SELECTION: We selected studies that were focused on examining the effect of school-based PA interventions on cardiometabolic risk factors in children.
DATA EXTRACTION: Random-effects models were used to calculate the pooled effect size (ES) for the included cardiometabolic risk factors (waist circumference [WC], triglycerides, total cholesterol, high-density lipoprotein cholesterol, low-density lipoprotein cholesterol, systolic blood pressure and diastolic blood pressure (DBP), and fasting insulin and glucose).
RESULTS: Nineteen randomized controlled trials (which included 11 988 children aged 3–12 years) were included in the meta-analysis. School-based PA programs were associated with a significant small improvement in WC (ES = −0.14; 95% confidence interval [CI]: −0.22 to −0.07; P < .001), DBP (ES = −0.21; 95% CI: −0.42 to −0.01; P = .040), and fasting insulin (ES = −0.12; 95% CI: −0.20 to −0.04; P = .003).
LIMITATIONS: Authors of few studies described the implementation conditions of their interventions in detail, and compliance rates were lacking in most studies. In addition, results by sex were provided in a small number of studies.
CONCLUSIONS: School-based PA interventions improve some cardiometabolic risk factors in children, such as WC, DBP, and fasting insulin.</td></tr>
<tr><td>Timeframe: Inception until February 22 2018</td></tr>
<tr><td>Total # studies included: 19</td></tr>
<tr><td>Other details (e.g. definitions used, exclusions etc) All studies were RCT</td></tr>
<tr><td>Outcomes addressed: Cardio-metabolic risk factors (waist circumference, triglycerides, total cholesterol, LDL cholesterol, blood pressure, insulin and glucose)</td></tr>
</table>

<table>
<tr><td colspan="2">SR/MA
Citation: Singh AS, Saliasi E, van den Berg V, et al. Effects of physical activity interventions on cognitive and academic performance in children and adolescents: a novel combination of a systematic review and recommendations from an expert panel. Br J Sports Med 2019;53:640-47</td></tr>
<tr><td>Purpose: To summarise the current evidence on the effects of physical activity (PA) interventions on cognitive and academic performance in children, and formulate research priorities and recommendations.

Timeframe: Until September 2017

Total # studies included: 58

Other details (e.g. definitions used, exclusions etc) 11 studies with high quality selected for evidence synthesis. No adverse effects of PA on any outcome.

Outcomes addressed: At least one cognitive or academic performance</td>
<td>Abstract:
Objective To summarise the current evidence on the effects of physical activity (PA) interventions on cognitive and academic performance in children, and formulate research priorities and recommendations.
Design Systematic review (following PRISMA guidelines) with a methodological quality assessment and an international expert panel. We based the evaluation of the consistency of the scientific evidence on the findings reported in studies rated as of high methodological quality.
Data sources PubMed, PsycINFO, Cochrane Central, Web of Science, ERIC, and SPORTDiscus.
Eligibility criteria for selecting studies PA intervention studies in children with at least one cognitive or academic performance assessment.
Results Eleven (19%) of 58 included intervention studies received a high-quality rating for methodological quality: four assessed effects of PA interventions on cognitive performance, six assessed effects on academic performance, and one on both. All high-quality studies contrasted the effects of additional/adapted PA activities with regular curriculum activities. For cognitive performance 10 of 21 (48%) constructs analysed showed statistically significant beneficial intervention effects of PA, while for academic performance, 15 of 25 (60%) analyses found a significant beneficial effect of PA. Across all five studies assessing PA effects on mathematics, beneficial effects were reported in six out of seven (86%) outcomes. Experts put forward 46 research questions. The most pressing research priority cluster concerned the causality of the relationship between PA and cognitive/academic performance. The remaining clusters pertained to PA characteristics, moderators and mechanisms governing the ’PA–performance’ relationship and miscellaneous topics.
Conclusion There is currently inconclusive evidence for the beneficial effects of PA interventions on cognitive and overall academic performance in children. We conclude that there is strong evidence for beneficial effects of PA on maths performance. The expert panel confirmed that more ’high-quality’ research is warranted. By prioritising the most important research questions and formulating recommendations we aim to guide researchers in generating high-quality evidence. Our recommendations focus on adequate control groups and sample size, the use of valid and reliable measurement instruments for physical activity and cognitive performance, measurement of compliance and data analysis.</td></tr>
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SR/MA **Citation:** Skrede T, Steene-Johannessen et al. The prospective association between objectively measured sedentary time, moderate-to-vigorous physical activity and cardiometabolic risk factors in youth: a systematic review and meta-analysis. *Obes Rev* 2019;20:55-74.	
Purpose: To summarize the evidence on a prospective relationship between objectively measured sedentary time, MVPA and cardiometabolic health indicators in youth. **Timeframe:** Jan. 2000 – April 2018 **Total # studies included:** 30 **Other details** Evidence was from prospective studies only. **Outcomes addressed:** Cardiometabolic health	**Abstract:** Sedentary time and moderate-to-vigorous physical activity (MVPA) may be uniquely related to cardiometabolic health. Excessive sedentary time is suggested as an independent cardiometabolic risk factor, while MVPA is favourably associated with cardiometabolic health. This systematic review and meta-analysis summarizes the evidence on a prospective relationship between objectively measured sedentary time, MVPA and cardiometabolic health indicators in youth. PubMed, Embase, CINAHL, PhyscINFO and SPORTDiscus were systematically searched from January 2000 until April 2018. Studies were included if sedentary time and physical activity were measured objectively and examined associations with body mass index, waist circumference, triglycerides, high-density lipoprotein, insulin, blood pressure or the clustering of these cardiometabolic risk factors. We identified 30 studies, of which 21 were of high quality. No evidence was found for an association between sedentary time and cardiometabolic outcomes. The association between MVPA and individual cardiometabolic risk factors was inconsistent. The meta-analysis for prospective studies found a small but significant effect size between MVPA at baseline and clustered cardiometabolic risk at follow-up (ES –0.014 [95% CI, 0.024 to 0.004]).We conclude that there is no prospective association between sedentary time and cardiometabolic health, while MVPA is beneficially associated with cardiometabolic health in youth.

<table>
<tr><td colspan="2">SR/MA
Citation: Stanczykiewicz B, Banik A, Knoll N et al. Sedentary behaviors and anxiety among children, adolescents and adults: a systematic review and meta-analysis. BMC Public Health. 2019;9:459</td></tr>
<tr><td>Purpose: summarize the evidence for the SB--anxiety relationship.
(1) synthesize the associations between SB and anxiety symptoms and (2) examine if SB-anxiety associations are moderated by the age group (children/adolescents vs. adults), participants' health status (general population vs. people with a chronic physical or mental illness).</td><td rowspan="5">Abstract:
Background: Although the number of studies examining the relationships between sedentary behaviors (SB) and anxiety is growing, an overarching evidence, taking into account children, adolescents, and adults as well as different types of SB and different categories of anxiety outcomes, is still missing. Thus, this systematic review and meta-analysis aimed at obtaining a comprehensive overview of existing evidence.
Methods: A search in the following databases: PsycINFO, PsycARTICLES, Academic Search Complete, ERIC, HealthSource: Nursing/Academic Edition and MEDLINE, resulted in k = 31 original studies included in the systematic review (total N = 99,192) and k = 17 (total N = 27,443) included in the meta-analysis. Main inclusion criteria referred to testing the SB--anxiety relationship, the quality score (above the threshold of 65%), and the language of publications English). The study was following the PRISMA statement and was registered at PROSPERO (CRD42017068517).
Results: Both the systematic review and meta-analysis indicated that overall average effects were small: higher levels of symptoms of anxiety were associated with higher levels of SB (weighted r = .093, 95% CI [.055, .130], p < .001). Moderator analyses indicated that trends for stronger effects were observed among adults, compared to children/ adolescents (p = .085).
Conclusions: Further longitudinal studies are necessary to elucidate the predictive direction of the anxiety—SB relationship and to clarify whether the effects depend on the type of anxiety indicators.</td></tr>
<tr><td>Timeframe:</td></tr>
<tr><td>Total # studies included: 31</td></tr>
<tr><td>Other details (e.g. definitions used, exclusions etc)
Most studies were x-sectional. Seven prospective and 3 RCT included</td></tr>
<tr><td>Outcomes addressed: Anxiety</td></tr>
</table>

SR/MA **Citation:** Verswijveren SJMM, Lamb KE, Bell LA et al. Associations between activity patterns and cardio-metabolic risk factors in children and adolescents: A systematic review. *PLOS One* 2018; 13(8): e0201947.	
Purpose: To synthesise the evidence concerning associations between activity patterns and cardio-metabolic risk factors in children and adolescents aged 5±19 years. **Timeframe:** 1980 to 2017 **Total # studies included:** 29 **Other details (e.g. definitions used, exclusions etc)** Device-measured PA and sedentary patterns. 24 observational (76% x-sectional) and five interventions **Outcomes addressed:** Cardio-metabolic risk factors (i.e., adiposity, blood lipids, inflammatory biomarkers, endothelial function biomarkers, blood glucose, vascular health, fitness, or summary cardio-metabolic scores)	**Abstract:** **Introduction** Total volumes of physical activity and sedentary behaviour have been associated with cardio-metabolic risk profiles; however, little research has examined whether patterns of activity (e.g., prolonged bouts, frequency of breaks in sitting) impact cardio-metabolic risk. The aim of this review was to synthesise the evidence concerning associations between activity patterns and cardio-metabolic risk factors in children and adolescents aged 5±19 years. **Materials and methods** A systematic search of seven databases was completed in October 2017. Included studies were required to report associations between objectively-measured activity patterns and cardio-metabolic risk factors in children and/or adolescents, and be published between 1980 and 2017. At least two researchers independently screened each study, extracted data, and undertook risk of bias assessments. **Results** From the 15,947 articles identified, 29 were included in this review. Twenty-four studies were observational (cross-sectional and/or longitudinal); five were experimental. Ten studies examined physical activity patterns, whilst 19 studies examined sedentary patterns. Only one study examined both physical activity and sedentary time patterns. Considerable variation in definitions of activity patterns made it impossible to identify which activity patterns were most beneficial to children's and adolescents' cardio-metabolic health. However, potential insights and current research gaps were identified. **Discussion and conclusion** A consensus on how to define activity patterns is needed in order to determine which activity patterns are associated with children's and adolescents' cardio-metabolic risk. This will inform future research on the impact of activity patterns on children's and adolescents' short- and longer-term health.

<table>
<tr><td colspan="2">Meta-Analysis
Citation: Xue Y, Yang Y, Huang T. Effects of chronic exercise interventions on executive function among children and adolescents: a systematic review with meta-analysis. Br J Sports Med. 2019 Feb 8;(1):1–9.</td></tr>
<tr><td>Purpose: To synthesise randomised controlled trials (RCTs) regarding the effects of chronic exercise interventions on different domain-specific executive functions (EFs) among children and adolescents.</td><td rowspan="5">Abstract:
OBJECTIVE: To synthesise randomised controlled trials (RCTs) regarding the effects of chronic exercise interventions on different domain-specific executive functions (EFs) among children and adolescents.
DESIGN: Systematic review with meta-analysis.
DATA SOURCES: PsycINFO, PubMed, SPORTDiscus, Academic Search Premier, Embase and Web of Science were searched.
ELIGIBILITY CRITERIA FOR SELECTING STUDIES: RCTs or cluster RCT design, which employ chronic exercise interventions and target healthy children (age 6-12 years) and adolescents (age 13-17 years). We defined chronic exercise as physical activity (PA) which consists of multiple exercise sessions per week and lasts for an extended period of time (typically over 6 weeks).
RESULTS: We included 19 studies, with a total of 5038 participants. The results showed that chronic exercise interventions improved overall EFs (standardised mean difference (SMD)=0.20, 95% CI 0.09 to 0.30, p<0.05) and inhibitory control (SMD=0.26, 95% CI 0.08 to 0.45, P<0.05). In meta regression, higher body mass index was associated with greater improvements in overall EFs performance (β=0.03, 95% CI 0.0002 to 0.06, p<0.05), whereas age and exercise duration were not. In subgroup analysis by intervention modality, sports and PA programme (SMD=0.21, 95% CI 0.12 to 0.31, p<0.05) and curricular PA (SMD=0.39, 95% CI 0.08 to 0.69, p<0.05) improved overall EFs performance, but integrated PA did not (SMD=0.02, 95% CI -0.05 to 0.09, p>0.05). Interventions with a session length < 90 minutes improved overall EFs performance (SMD=0.24, 95%CI 0.10 to 0.39, p=0.02), but session length ≥ 90 minutes did not (SMD=0.05, 95%CI -0.03 to 0.14). No other moderator was found to have an effect.
CONCLUSIONS: Despite small effect sizes, chronic exercise interventions, implemented in curricular or sports and PA programme settings, might be a promising way to promote multiple aspects of executive functions, especially inhibitory control.</td></tr>
<tr><td>Timeframe: Not reported.</td></tr>
<tr><td>Total # studies included: 19</td></tr>
<tr><td>Author’s Definition of chronic exercise: Physical activity which consists of multiple exercise sessions per week and lasts for an extended period of time (typically over 6 weeks).</td></tr>
<tr><td>Outcomes addressed: Executive function (i.e., cognition flexibility, inhibitory control, working memory and planning)</td></tr>
<tr><td>Populations analysed: children and adolescents</td><td>Author-stated funding source: TH was supported by Shanghai Pujiang Program (16PJC052) and the research project from General Administration of Sport of China (2017B044).</td></tr>
</table>

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