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).*(26)* 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**	**Indirect-ness**	**Imprecision**	**Other**	**Summary of findings[a]**	**Certainty**	**US PAGAC evidence *(27)***
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 indirect-ness[d]	No serious imprecision Serious imprecision	New systematic reviews were limited to specific physical activity interventions (laboratory-based HIIT, classroom-based active learning, resistance training)	Collins et al. 2018 *(7)* (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 *(8)* (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 *(16)*: (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. 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]	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**
11 NRT[g] n=4,552	Serious risk of bias[h]	No serious inconsistency	Serious of indirect-ness[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).	VERY LOW[j]	

No reviews limited to NRTs identified.						**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).		
19 Longitudinal [k] n=28,141	Serious risk of bias[l]	No serious inconsistency	No serious indirect-ness	No serious imprecision	NR	Miguel-Berges et al. 2018 *(17)*: (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). **FFM** ***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 indirect-ness	No serious imprecision	NR	Miguel-Berges et al. 2018 *(17)*: (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 *(18)*: (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.	VERY LOW[q]	

						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). **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). Enrolment 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 analysed 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.