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 developed to support the development of the 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**	**Indirectness**	**Imprecision**	**Other**	**Summary of findings**	**Certainty**	For reference: Summary from PAGAC ***(27)***
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 *(6)* (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 up (Eather et al. 2013). **No reviews reporting strength and endurance outcomes identified.** **Flexibility:**	LOW[e]	15 ESRs Strong evidence demonstrates that, in children and adolescents, higher amounts of physical activity are associated with more favourable status for cardiorespiratory and muscular fitness. **PAGAC Grade: Strong** Strong evidence demonstrates that increased moderate-to-vigorous physical activity increases

						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.**		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. 2013*(28)*; Santos et al. 2018).	LOW[m]	
48 Cross-sectional[n] N = 14,985 **No reviews including or limited to longitudina**	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; Hjorth et al. 2013; Lambourne et al. 2013; Larouche et al. 2014; Hansen et al. 2014; Saavedra et al. 2014), or mixed	VERY LOW[u]	

l designs identified.						(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. 2013).

[k] Serious imprecision. Wide confidence intervals for dose-response trend (Carson et al. 2013).

[l] There was a positive, dose-response gradient between VPA and aerobic fitness (Carson et al. 2013).

[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.