



Meeting the Australian 24-Hour Movement Guidelines for the Early Years is associated with better social-emotional development in preschool boys

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ABSTRACT

24-hour Movement Guidelines for the Early Years promote that achieving all three-movement behaviour (sleep, sedentary behaviour and physical activity) recommendations is important for child health and development. We examined the association between meeting all, none and combinations of the Australian 24-Hour Movement Guidelines for the Early Years and social-emotional development in 1363 preschool (2–5 years) boys (52%) and girls. The PLAYCE study (Perth, Western Australia) parent survey collected data on children's social-emotional development (Strengths & Difficulties Questionnaire), screen time, sleep and socio-demographic factors. Physical activity was measured using seven-day accelerometry. Only 8% of preschoolers met all three guidelines (5% met none). A higher proportion of boys than girls met physical activity-related guideline combinations (physical activity only, physical activity plus screen, physical activity plus sleep, all), while more girls than boys met sleep only guidelines (all $p < 0.05$). In boys, meeting all guidelines, compared with none, was associated with a lower total difficulties score (adjusted difference in means -1.90 ; 95%CI: $-3.88, -0.10$). Meeting the screen only guideline or the screen plus sleep guidelines, compared with none, were associated with lower total difficulties, conduct problems and hyperactivity scores in boys (all $p < 0.05$). Meeting the physical activity plus sleep guidelines, compared with none, were associated with lower total difficulties and conduct problems scores in boys (all $p < 0.05$). No significant associations were found for girls. These findings highlight the positive impact for boys social-emotional development in meeting all guidelines. Future guideline development should consider dose–response evidence to identify guideline thresholds for specific health and developmental outcomes for boys and girls.

1. Introduction

The early (0–5) years are critical for the development of key behaviours, such as regular physical activity, adequate sleep and minimising time spent sedentary (Okely et al., 2017). The establishment of such behaviours provides the foundation for optimal growth and development and lifelong health (Jones et al., 2013). The World Health Organization, as well as several countries have released '24-hour Movement Guidelines for the Early Years'. These Guidelines emphasise that the 'whole day matters' and consider sleep, sedentary behaviour and physical activity as three co-dependent behaviours (Australian

Government Department of Health, 2017). The Guidelines promote that achieving all three movement behaviour recommendations is more important for child health and development, rather than focusing on the attainment of a single recommendation (Chaput et al., 2017).

Sufficient sleep and physical activity as well as limiting sedentary behaviour are recognised as important for young children's social-emotional development (Carson et al., 2019; Cliff et al., 2017; Timmons et al., 2007). Social-emotional development involves children building skills to understand and manage their own feelings, understand emotional states in others, regulate their behaviour, develop empathy and sustain relationships with others (Hamilton and Redmond, 2010).

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These skills form the basis of self-regulation which enables children to focus their attention, remember instructions, plan and do multiple tasks well (Centre on the Developing Child, 2015). Findings from a meta-analysis of 66 studies confirmed a small but significant sex difference in social-emotional development, with girls having more positive emotions and internalizing emotions than boys, and boys showing more externalising emotions than girls (Chaplin and Aldao, 2013). This is likely due to a combination of innate predispositions and socialisation into culturally identified gender roles (Maguire et al., 2016).

Systematic reviews to inform the development of Canadian and Australian '24-hour Movement Guidelines for the Early Years' confirm that regular physical activity supports young children's psychosocial development (e.g., social competence, internalizing and externalising behaviour problems, emotionality, conduct problems) (Carson et al., 2017; Timmons et al., 2012). In addition, sedentary behaviour, primarily screen time, is associated with sub-optimal psychosocial development (LeBlanc et al., 2012; Poitras et al., 2017) and shorter sleep duration is associated with poorer emotional regulation (Chaput et al., 2017). The most ideal combination of physical behaviours for optimal social-emotional development in the early years is assumed to be greater levels of sleep, low levels of sedentary time and high levels of physical activity. However, in a recent review (Feng et al., 2021) only three studies examined the interaction between meeting different movement behaviour guidelines simultaneously and their relationship with preschool children's social-emotional development (Carson et al., 2019; Cliff et al., 2017; McNeill et al., 2020). These studies examined the number and combinations of meeting guidelines separately, used different instruments to measure social-emotional development, did not examine sex differences, and had small sample sizes (except for Carson et al., 2019), making comparison of findings difficult. Given the established sex differences in preschooler physical activity (Hinkley et al., 2008) it is important studies examine results by sex.

It is possible that meeting some movement behaviour guideline combinations (number of and type) may be more or less positively associated with young children's social-emotional development, compared with meeting no guidelines. These relationships may also differ for boys and girls based on existing evidence of the sex differences in preschool children's physical activity (Hinkley et al., 2008) and social-emotional development (Chaplin and Aldao, 2013). Thus, the aim of this study was to determine the association between meeting all, none and combinations of the Australian 24-Hour Movement Guidelines for the Early Years and social-emotional development in preschool boys and girls.

2. Methods

2.1. Study design and participants

This study formed part of the Play Spaces and Environments for Children's Physical Activity (PLAYCE) study (Christian et al., 2016). PLAYCE was a cross-sectional observational study (2015–2018) of 1,596 preschool children, clustered by childcare centre ($n = 104$) across the Perth Metropolitan area, Western Australia. Centres were recruited based on size (small and large based on the number of approved places) and across socio-economic status. Centre Directors first provided their informed consent and through consultation with centre staff, parents and their child aged 2–5 years were invited to participate. Further details about the PLAYCE study protocol and baseline findings have been previously published (Christian et al., 2016; Christian et al., 2018). A total of 1363 children with no missing data for all variables were included in the current sub-study (233 participants had missing data for one or more of the variables in the main study). This study met the University of Western Australia's guidelines for the protection of human subjects concerning their safety and privacy and ethics approval was granted by The University of Western Australia Human Research Ethics Committee (RA/4/1/7417).

2.2. Measures

2.2.1. Social-emotional development

Children's socio-emotional development was measured using the total difficulties score and five sub-scale scores from the Strengths and Difficulties Questionnaire (SDQ); emotional symptoms, conduct problems, hyperactivity-inattention, peer problems and prosocial behaviour as reported by parents in the PLAYCE survey. Each sub-scale includes five items rated on a 3-point scale ('not true'; 'somewhat true'; 'certainly true'). The higher the score the higher the level of social-emotional difficulties, except for prosocial behaviour (whereby higher scores reflect more helpful prosocial behaviours). The prosocial behaviour sub-scale was not included in the total difficulties score as per SDQ protocol (Youthinmind, 2016). The SDQ is a widely used and validated population-based child development questionnaire for 3–16 year olds (Goodman, 1997; Goodman et al., 2003).

2.2.2. Physical activity

Hip worn ActiGraph GT3X+ accelerometers assessed the frequency, duration and intensity of physical activity during the waking hours over a 7 day monitoring period (Christian et al., 2016). There is moderate-to-strong evidence of accelerometer validity for measuring daily time spent in light, moderate and vigorous intensity physical activity in young children (Pate et al., 2010; Trost et al., 2012). Sampling intervals were set to 15secs to accommodate the sporadic nature of young children's physical activity. Cut-points developed by Pate and colleagues were used to distinguish between different intensities of physical activity (Pate et al., 2006). Average minutes per day of light, moderate, vigorous and total physical activity (sum of light, moderate and vigorous physical activity) per day were calculated. Data were included in the analysis if participants had at least 4 days (including at least 1 weekend day) with a minimum 8 h wear time/day. Non-wear time was defined as intervals with at least 20 consecutive minutes of zero counts (Christian et al., 2016). A total of 1368 (86%) of children had sufficient valid accelerometer data.

2.2.3. Screen time

Parents reported the amount of sedentary, recreational screen time their child accumulated in a typical week on: a) Monday to Friday; and b) Saturday and Sunday (e.g., 'Thinking about the last month, which of the following indoor leisure activities does your child usually do in a typical week?'). Items included TV/DVD; non-movement-based game consoles; computer; tablet; and smartphone. Items were based on existing items shown to be reliable for use in this age group (Hinkley et al., 2012).

2.2.4. Sleep

Parents reported the duration their child usually sleeps in a 24-hour period during the night and day (e.g., 'About how many hours and minutes does your child usually sleep in total...during the night?...during the day?'). These were established items from the Growing Up in Australia: The Longitudinal Study of Australian Children Survey (Christian et al., 2016; Sanson et al., 2005).

2.2.5. Meeting 24-hour movement guidelines for the early years

Children were defined as meeting guidelines based on the Australian 24-hr Movement Guidelines for the Early Years: total physical activity of ≥ 180 mins/day (of which ≥ 60 mins/day is moderate-vigorous physical activity (MVPA) for 3–5 year olds); sedentary leisure screen time of ≤ 60 mins/day; sleep 11–14 h/day for 1–2 year olds and 10–13 h/day for 3–5 year olds (Australian Government Department of Health, 2017). Eight dichotomous variables were calculated to identify children meeting no guidelines, all three guidelines, any single guideline only (i.e., physical activity only, sleep only, screen time only) and combinations of meeting any two guidelines (i.e., physical activity and screen time, physical activity and sleep, sleep and screen time).

Table 1
Characteristics of PLAYCE preschooler study cohort (Perth, Western Australia 2015–2018).

Characteristic	Total sample (n = 1,363) ¹ Mean (SD) or n (%)	Boys (n = 709) Mean (SD) or n (%)	Girls (n = 654) Mean (SD) or n (%)	p-value
Child mean age	3.30 (0.69)	3.27 (0.69)	3.33 (0.68)	0.167
Siblings	913 (67.0)	481 (67.8)	432 (66.1)	0.483
Parent sex - female	1,237 (91.0)	636 (89.8)	601 (92.2)	0.132
Parent education				0.131
Less than secondary	67 (4.9)	31 (4.4)	36 (5.5)	
Year 12/Trade/Diploma	515 (37.8)	285 (40.2)	230 (35.2)	
Tertiary degree	781 (57.3)	393 (55.4)	388 (59.3)	
Marital status				0.554
Single/Widowed/Separated/Divorced	139 (10.2)	69 (9.7)	70 (10.7)	
Married/De facto	1,224 (89.8)	640 (90.3)	584 (89.3)	
Work status				0.623
Full-time work	462 (33.9)	243 (34.3)	219 (33.5)	
Part-time work	648 (47.5)	340 (48.0)	308 (47.1)	
Not working	108 (7.9)	58 (8.2)	50 (7.6)	
Home duties	145 (10.6)	68 (9.6)	77 (11.8)	
Work status partner				0.531
Full-time work	1,117 (82.0)	585 (82.5)	532 (81.3)	
Part-time work	74 (5.4)	43 (6.1)	31 (4.7)	
Not working	35 (2.6)	15 (2.1)	20 (3.1)	
Home duties	14 (1.0)	7 (1.0)	7 (1.1)	
No partner	123 (9.0)	59 (8.3)	64 (9.8)	
Total PA (mins/day)	162.8 (37.7)	169.9 (39.9)	155.0 (33.4)	< 0.001
Light PA (mins/day)	82.7 (14.9)	84.2 (15.5)	80.9 (14.0)	< 0.001
MVPA (mins/day)	80.1 (25.9)	85.7 (27.8)	74.0 (22.1)	< 0.001
Accelerometer wear time (mins/day)	637.3 (63.9)	641.5 (66.5)	632.7 (60.5)	0.010
Screen time (mins/day)	106.7 (78.2)	104.3 (71.7)	109.4 (84.7)	0.230
Sleep time (hours/day)	11.45 (1.25)	11.48 (1.27)	11.42 (1.23)	0.407
% meeting Australian 24-Hr Movement Guidelines for the Early Years ²				< 0.001
None	67 (4.9)	34 (4.8)	33 (5.0)	
PA only	30 (2.2)	23 (3.2)	7 (1.1)	
Screen only	39 (2.9)	23 (3.2)	16 (2.4)	
Sleep only	550 (40.4)	237 (33.4)	313 (47.9)	
PA and Screen	14 (1.0)	11 (1.6)	3 (0.5)	
PA and Sleep	273 (20.0)	185 (26.1)	88 (13.5)	
Screen and Sleep	281 (20.6)	130 (18.3)	151 (23.1)	
PA and Screen and Sleep	109 (8.0)	66 (9.3)	43 (6.6)	
Social-emotional development ³				
SDQ total difficulties score	8.72 (4.49)	9.11 (4.62)	8.30 (4.30)	< 0.001
Emotional difficulties score	1.43 (1.39)	1.36 (1.34)	1.49 (1.44)	0.085
Conduct problems score	2.17 (1.76)	2.31 (1.89)	2.02 (1.60)	0.002
Hyperactivity score	3.84 (2.19)	4.10 (2.19)	3.56 (2.16)	< 0.001
Peer problems score	1.28 (1.39)	1.33 (1.43)	1.22 (1.34)	0.124
Prosocial behaviour score	7.42 (1.77)	7.17 (1.83)	7.70 (1.67)	< 0.001

PA = physical activity; MVPA = moderate to vigorous intensity physical activity; SDQ = Strengths and Difficulties Questionnaire.

¹ Analyses restricted to those with non-missing data for all variables (n = 1363).

² Categories of meeting guidelines are mutually exclusive.

³ The higher the score, the higher the level of social-emotional difficulties reported by parents except for prosocial behaviour (higher scores reflect more helpful prosocial behaviours).

2.2.6. Socio-demographic factors

The PLAYCE parent survey included standard items measuring child age and sex, presence of siblings, parent education (Less than secondary, Year 12/Trade/Diploma, Tertiary degree), marital status (Single/Widowed/Separated/Divorced, Married/De facto), parent work status (Full-time work, Part-time work, Not working, Home duties) and partner work status (Full-time work, Part-time work, Not working, Home duties, No partner).

2.3. Statistical analysis

Descriptive analyses were first undertaken. Independent sample t-tests and chi square analysis were used to confirm differences between boys and girls for socio-demographic, movement behaviours and social-emotional development. Linear regression models were used to determine the association between meeting 24-hr movement guidelines (an eight-level factor describing the different combinations of meeting the three guidelines) and preschooler SDQ total difficulties, emotional

difficulties, conduct problems, hyperactivity, peer problems and prosocial behaviour scores. All models adjusted for child age, siblings, parent education, marital status, work status, partner work status and accounted for clustering of children by childcare centre recruited from by the inclusion of random effects (intercept). Based on evidence of differences in preschool boys and girls physical activity levels and social-emotional development (as measured by the SDQ), separate models were run for boys and girls. In addition, model covariate coefficients were found to be different for boys and girls suggesting that fitting a sex by guideline interaction term would not be appropriate. Analyses were conducted for meeting all three guidelines, any one single guideline only and combinations of meeting any two guidelines only, compared with meeting no guidelines. Other guideline reference groups (e.g., the most commonly met; sleep only) were considered however, meeting no guidelines as the reference group provided the best option for interpretation of findings. Results show the adjusted difference in means of SDQ scores between meeting different combinations of guidelines and meeting no guidelines (reference category).

3. Results

3.1. Sample socio-demographic, movement behaviour and social-emotional development characteristics

Children were on average 3.3 (SD 0.7) years old, 52% were boys and 67% had siblings (Table 1). Most parents were female (91%), married (90%), had a tertiary degree (57%), either worked full- (34%) or part-time (47%) and had partners who worked full-time (82%). There were no significant socio-demographic differences between boys and girls.

On average, children accumulated 163 (SD 38) mins/day of total physical activity, of which approximately half was MVPA (mean 80; SD 26) and half was light physical activity (mean 83; SD 15) (Table 1). Boys accumulated significantly more mins/day of total, MVPA and light physical activity, compared with girls (e.g., mean total physical activity: boys 170, girls 155; $p < 0.001$). On average, children accumulated 107 (SD 78) mins/day recreational screen time and 11.4 (SD 1.2) hours/day sleep, with no significant difference between boys and girls.

The mean SDQ total difficulties score was 8.7 (SD 4.5) with boys scoring significantly higher than girls ($p < 0.001$) (Table 1). Boys also scored significantly higher than girls on the conduct problems ($p = 0.002$) and hyperactivity sub-scales ($p < 0.001$), while girls scored significantly higher than boys on the prosocial behaviour sub-scale ($p < 0.001$).

Overall, 31.2% met physical activity, 32.5% met screen, and 89.0% met sleep guidelines. For meeting one guideline only, 2.2% met physical activity only, 2.9% met screen time only and 40.4% met sleep only. For two guidelines only, 1.0% met physical activity and screen, 20.0% met physical activity and sleep and 20.6% met screen and sleep. Only 8.0% met all three and 4.9% met no guidelines. A significantly higher proportion of boys than girls met the physical activity guideline, the physical activity and screen guideline, and the physical activity and sleep guideline and all three guidelines, while more girls than boys met the sleep guideline (all $p < 0.05$) (Figs. 1 and 2).

3.2. Associations between meeting 24-hour movement guidelines and social-emotional development

In boys, meeting all three guidelines compared with none was significantly associated with a lower mean SDQ total difficulties score (adjusted difference in means -1.99 ; 95% CI: -0.10 , -3.88 ; $p = 0.0392$). There were no significant relationships between meeting all three guidelines and any of the SDQ sub-scale scores or between meeting any combinations of guidelines and boys emotional difficulties, peer problems or pro-social behaviour.

In boys, after adjustment for child and parent socio-demographic factors and childcare centre attended, meeting screen only guidelines compared with meeting no guidelines was significantly associated with a lower mean SDQ total difficulties score (adjusted difference in means -3.51 ; 95% CI: -1.12 , -5.90 ; $p = 0.004$), a lower conduct problems score (adjusted difference in means -1.47 ; 95% CI: -0.49 , -2.46 ; $p = 0.003$) and a lower hyperactivity score (adjusted difference in means -1.35 ; 95% CI: -0.22 , -2.49 ; $p = 0.020$) (Table 2). There were no significant relationships between SDQ scores and meeting physical activity guideline only or sleep guideline only, compared with no guideline.

In boys, meeting both screen and sleep guidelines compared with no guidelines was significantly associated with a lower mean SDQ total difficulties score (adjusted difference in means -2.00 ; 95% CI: -0.29 , -3.72 ; $p = 0.022$), a lower conduct problems score (adjusted difference in means -0.83 ; 95% CI: -0.12 , -1.54 ; $p = 0.022$) and lower hyperactivity score (adjusted difference in means -0.89 ; 95% CI: -0.08 , -1.71 ; $p = 0.032$) (Table 2b). Meeting both physical activity and sleep guidelines compared with no guidelines was significantly associated with a lower mean SDQ total difficulties score (adjusted difference in means -1.84 ; 95% CI: -0.15 , -3.54 ; $p = 0.033$) and conduct problems

score (adjusted difference in means -0.74 ; 95% CI: -0.04 , -1.43 ; $p = 0.039$). There were no significant differences in SDQ scores for boys meeting physical activity and screen guidelines, compared with boys meeting no guidelines.

For girls, meeting the guideline for just one behaviour, or combinations of two or three behaviours compared with meeting no guidelines were not significantly associated with any SDQ scores (Table 3).

4. Discussion

Overall, only 8% of preschool children met all three 24-hour movement guidelines for the early years and 5% met none. These findings are generally consistent with other studies of preschooler prevalence of meeting 24-hour movement guidelines (Feng et al., 2021). While there is strong evidence that preschool boys are more active than girls (Hinkley et al., 2008), no studies to date appear to have examined differences between preschool boys and girls meeting 24-hour movement guidelines. We found that a higher proportion of boys than girls met physical activity-related guideline combinations (physical activity only, physical activity and screen, physical activity and sleep and all three guidelines), while more girls than boys met sleep only guidelines.

To our knowledge, this is the largest study to examine the relationship between social-emotional development and meeting 24-hour movement guidelines in preschool boys and girls. Meeting any or a combination of 24-hour movement guidelines for the early years was associated with social-emotional development in boys, but not girls. Specifically, meeting the screen guideline only, screen and sleep guidelines, physical activity and sleep guidelines, and all three guidelines, compared with meeting no guidelines was associated with less total difficulties, conduct problems and hyperactivity in boys. The odds of children developing a clinically significant mental health disorder have been found to increase by between 14 and 28% for each one-point increase in the total SDQ score (Goodman and Goodman, 2009). There was a two-point mean difference in the total SDQ score for boys meeting all three guidelines compared with meeting no guideline. These findings highlight the potential negative implications for social-emotional development and mental health if young boys, in particular do not meet the guidelines (Australian Government Department of Health, 2017).

Previous studies examining the relationship between meeting 24-hour movement guidelines and preschooler social-emotional development mostly report positive associations, with results varying depending on the number and combination of guidelines met and the measure of preschooler social-emotional development used (Carson et al., 2019; Cliff et al., 2017; McNeill et al., 2020). For example, in an Australian study of 248 preschool children, emotional understanding as measured

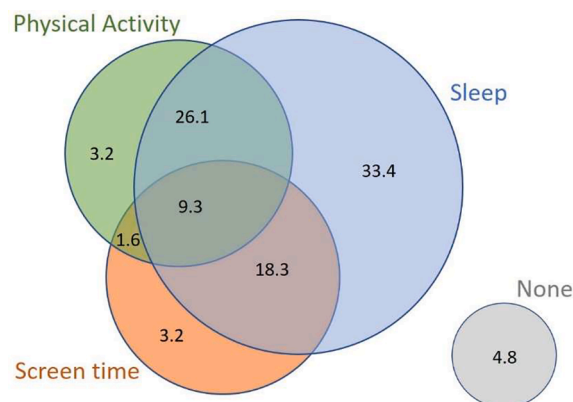


Fig. 1. Venn diagram of the proportion (%) of preschool boys meeting the different combinations of the three Australian 24-Hour Movement Guidelines for the Early Years (circle size is proportional to the % meeting guidelines; PLAYCE study, Perth, Western Australia 2015–2018).

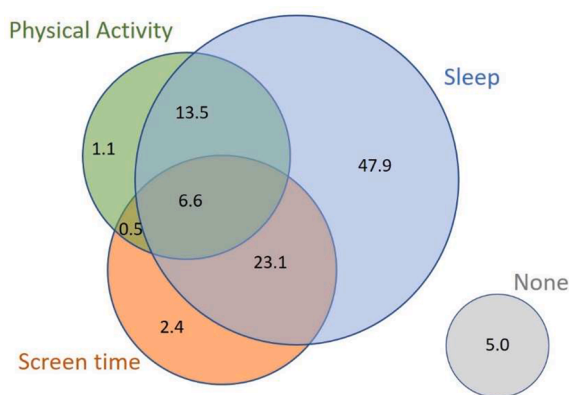


Fig. 2. Venn diagram of the proportion (%) of preschool girls meeting the different combinations of the three Australian 24-Hour Movement Guidelines for the Early Years (circle size is proportional to the % meeting guidelines; PLAYCE study, Perth, Western Australia 2015–2018).

by the Test of Emotional Comprehension (Pons et al., 2004) was positively associated with meeting the sleep only guideline, sleep and physical activity guidelines, and sleep and screen time guidelines (Cliff et al., 2017). Similarly, in a Canadian study of 539 3-year olds, meeting screen time and physical activity guidelines and, screen time and sleep guidelines was associated with lower scores for total, externalising and internalising problems as measured by the parent-report Child Behavior Checklist (Carson et al., 2019).

However, studies to date have adjusted for child sex and not examined relationships separately for boys and girls. We found that meeting 24-hour movement guidelines was positively associated with boys but not girls social-emotional development. Why we did not observe an association in girls is unclear. It may relate to boys in this sample having

significantly higher SDQ scores (total difficulties, conduct problems and hyperactivity) than girls (Kremer et al., 2015). This is consistent with other studies reporting boys score higher on the SDQ scale than girls (Hawes and Dadds, 2004; Klein et al., 2012; Kremer et al., 2015; Maguire et al., 2016). It is also possible that the SDQ scores are impacted by the sex of the parent completing the survey (mostly mothers) and the influence of culturally identified gender roles. Furthermore, potential differences in the way girls and boys are educated and parented by their parents and carers may influence their SDQ scores. Our results need to be interpreted with caution given that some guideline variables examined consisted of a low number of girls (e.g., only three girls met the physical activity and screen time guidelines and only seven met the physical activity only guideline) and may not have provided sufficient power to detect significant differences. Further research is needed to confirm these findings and to better understand the mechanisms behind what might be driving the findings observed in boys and girls.

Other studies have shown that increased screen time is associated with poorer social-emotional development outcomes in preschool children. For example, studies conducted in the UK, Switzerland and Japan which also used the SDQ to measure preschooler social-emotional development reported that increased screen time is associated with hyperactivity, emotional symptoms, conduct problems and poorer prosocial behaviour (Cheng et al., 2010; Ebenecker et al., 2012; Griffiths et al., 2010). The potential mechanisms through which screen time may negatively impact preschooler social-emotional development may relate to the lack of parent or peer interaction involved with most screen-based activities. Many types of screen use (e.g., tablets and mobile phones) are performed in isolation without interaction with others. Since learning to navigate interactions with others is an important aspect of a child’s social-emotional development too much time spent engaged with screens could limit young children’s opportunities to interact with other children and adults and develop their social and emotional competence. Future research could explore the role of parenting practices on the

Table 2
Association between meeting Australian 24-Hour Movement Guidelines for the Early Years and Social-Emotional Development in Preschooler Boys (PLAYCE study, Perth, Western Australia 2015–2018).

Guidelines met:	SDQ total difficulties score		Emotional difficulties		Conduct problems		Hyperactivity		Peer problems		Prosocial behaviours	
	Adjusted difference in means (95% CI)	p-value	Adjusted difference in means (95% CI)	p-value	Adjusted difference in means (95% CI)	p-value	Adjusted difference in means (95% CI)	p-value	Adjusted difference in means (95% CI)	p-value	Adjusted difference in means (95% CI)	p-value
None (reference)	0.000		0.000		0.000		0.000		0.000		0.000	
PA only	0.187 (-2.203, 2.577)	0.878	-0.196 (-0.906, 0.514)	0.588	0.207 (-0.779, 1.192)	0.681	0.222 (-0.913, 1.357)	0.701	-0.121 (-0.874, 0.631)	0.752	0.342 (-0.619, 1.303)	0.485
Screen only	-3.510 (-5.898, -1.121)	0.004	-0.371 (-1.081, 0.340)	0.306	-1.473 (-2.460, -0.487)	0.003	-1.353 (-2.487, -0.218)	0.020	-0.407 (-1.160, 0.346)	0.288	0.657 (-0.304, 1.618)	0.180
Sleep only	-1.266 (-2.915, 0.384)	0.132	-0.021 (-0.509, 0.468)	0.934	-0.666 (-1.345, 0.013)	0.055	-0.521 (-1.304, 0.262)	0.192	-0.120 (-0.638, 0.399)	0.651	0.175 (-0.487, 0.838)	0.603
PA and Screen	2.274 (-0.789, 5.336)	0.145	-0.097 (-1.007, 0.814)	0.835	1.031 (-0.233, 2.296)	0.110	0.749 (-0.706, 2.204)	0.312	0.540 (-0.425, 1.506)	0.272	-0.053 (-1.285, 1.179)	0.932
PA and Sleep	-1.843 (-3.537, -0.148)	0.033	-0.416 (-0.918, 0.087)	0.105	-0.736 (-1.434, -0.038)	0.039	-0.502 (-1.306, 0.303)	0.221	-0.306 (-0.840, 0.227)	0.260	0.215 (-0.466, 0.896)	0.536
Screen and Sleep	-2.005 (-3.717, -0.292)	0.022	-0.254 (-0.763, 0.225)	0.327	-0.830 (-1.537, -0.123)	0.022	-0.892 (-1.706, -0.079)	0.032	-0.115 (-0.655, 0.425)	0.676	0.349 (-0.340, 1.038)	0.320
PA and Screen and Sleep	-1.989 (-3.881, -0.098)	0.039	-0.134 (-0.695, 0.427)	0.639	-0.513 (-1.293, 0.266)	0.196	-0.844 (-1.742, 0.054)	0.065	-0.560 (-1.155, 0.035)	0.065	0.525 (-0.235, 1.285)	0.175

PA = physical activity; SDQ = Strengths and Difficulties Questionnaire; 95%CI = 95% Confidence Interval. Adjusted for child age, siblings, parent education, marital status, work status, work status partner and clustering of children by childcare centre recruited from. p-values are for each guideline combination met compared with meeting no guidelines.

Table 3

Association between meeting Australian 24-Hour Movement Guidelines for the Early Years and Social-Emotional Development in Preschooler Girls (PLAYCE study, Perth, Western Australia 2015–2018).

Guidelines met:	SDQ total difficulties score		Emotional difficulties		Conduct problems		Hyperactivity		Peer problems		Prosocial behaviours	
	Adjusted difference in means (95% CI)	p-value	Adjusted difference in means (95% CI)	p-value	Adjusted difference in means (95% CI)	p-value	Adjusted difference in means (95% CI)	p-value	Adjusted difference in means (95% CI)	p-value	Adjusted difference in means (95% CI)	p-value
None (reference)	0.000		0.000		0.000		0.000		0.000		0.000	
PA only	2.387 (-1.087, 5.861)	0.178	0.712 (-0.457, 1.880)	0.232	0.429 (-0.881, 1.738)	0.520	1.293 (-0.459, 3.046)	0.148	-0.036 (-1.113, 1.042)	0.948	0.182 (-1.184, 1.548)	0.794
Screen only	-0.836 (-3.403, 1.732)	0.523	-0.677 (-1.541, 0.187)	0.124	-0.007 (-0.975, 0.961)	0.988	-0.152 (-1.448, 1.145)	0.818	-0.008 (-0.807, 0.790)	0.984	-0.136 (-1.146, 0.873)	0.791
Sleep only	-0.164 (-1.688, 1.361)	0.833	0.140 (-0.373, 0.654)	0.591	-0.074 (-0.649, 0.501)	0.800	-0.330 (-1.099, 0.440)	0.400	0.109 (-0.365, 0.583)	0.651	0.012 (-0.587, 0.612)	0.968
PA and Screen	1.069 (-3.953, 6.092)	0.676	-0.088 (-1.778, 1.602)	0.919	1.053 (-0.840, 2.946)	0.275	0.287 (-2.249, 2.822)	0.824	-0.215 (-1.776, 1.345)	0.787	0.859 (-1.116, 2.834)	0.393
PA and Sleep	0.466 (-1.241, 2.173)	0.592	0.068 (-0.507, 0.642)	0.816	0.357 (-0.287, 1.000)	0.277	0.181 (-0.681, 1.043)	0.680	-0.133 (-0.664, 0.398)	0.622	0.109 (-0.563, 0.780)	0.751
Screen and Sleep	-0.953 (-2.564, 0.658)	0.246	0.248 (-0.294, 0.790)	0.369	-0.465 (-1.072, 0.142)	0.133	-0.728 (-1.541, 0.085)	0.079	-0.009 (-0.510, 0.491)	0.970	0.222 (-0.412, 0.855)	0.492
PA and Screen and Sleep	0.312 (-1.632, 2.257)	0.752	0.097 (-0.557, 0.751)	0.771	0.017 (-0.716, 0.750)	0.963	0.233 (-0.749, 1.215)	0.641	-0.048 (-0.653, 0.556)	0.875	-0.009 (-0.774, 0.756)	0.982

PA = physical activity; SDQ = Strengths and Difficulties Questionnaire; 95%CI = 95% Confidence Interval.

Adjusted for child age, siblings, parent education, marital status, work status, work status partner and clustering of children by childcare centre recruited from. p-values are for each guideline combination met compared with meeting no guidelines.

relationship between preschooler movement behaviours and social-emotional development.

Evidence from a systematic review suggests that in the early years, shorter sleep duration is associated with poorer emotional regulation (Chaput et al., 2017). Importantly, sleep problems at the age of four predicts mental health problems in adolescence (Gregory and O’connor, 2002). Some research has suggested that the impact of sleep on emotional regulation in early childhood may be part of the causal pathway between sleep and later mental health problems (Gregory et al., 2004; Hysing et al., 2016). Furthermore, a recent meta-analysis reported that more screen time was associated with poorer sleep outcomes while more physical activity was associated with better sleep outcomes in young children (Janssen et al., 2020). This supports our own findings that meeting screen and sleep guidelines, and physical activity and sleep guidelines, compared with no guidelines was associated with better social-emotional development in boys.

This is one of the first studies to show that meeting all movement guidelines is positively associated with social-emotional development in boys but not girls. Carson et al. (2019) also reported a significant trend for meeting more guidelines and a lower score for total problems, externalising and internalising problems (Carson et al., 2019), however the results were not presented separately by sex. Future research should explore sex differences (and the mechanisms) between meeting guidelines and other health and development outcomes and examine which combinations of meeting movement guidelines are optimal for the health or developmental outcome of interest. Future guideline development should consider whether a one size fits all approach is appropriate and be guided by evidence of the impact of different guidelines and combinations of guidelines on different health and developmental outcomes. Dose-response evidence is required to identify guideline thresholds for specific health and developmental outcomes.

4.1. Strengths and limitations of the study

While a strength of this study is its examination of meeting all, some or no movement guidelines and the relationship with young children’s social-emotional development, its cross-sectional design limits causal conclusions. The sample were also mostly highly educated, married and working mothers which limits the generalisation of the findings to lower socio-economic status and single parent families. Moreover, two guideline groups had a low number of girls limiting the ability to detect significant differences. Physical activity was measured using accelerometers worn during waking hours, however both screen time and sleep were parent reported. Future research should include data from 24-hour accelerometry, consider using compositional data analysis techniques and examine the impact of specific types of screen use on social-emotional development in young boys and girls. Finally, future longitudinal studies should consider the relationships between sleep and social-emotional development in early childhood and the impact on school readiness (Bell et al., 2016; Davies et al., 2016) and behaviour and mental health later in childhood.

5. Conclusion

Very few preschool children met all three 24-hour movement guidelines with more boys meeting guidelines than girls. Meeting screen time guidelines, screen and sleep guidelines, sleep and physical activity guidelines and all three movement guidelines, compared with no guidelines was associated with better social-emotional development in boys but not girls. Physical activity, screen time and sleep are modifiable behaviours, thus ensuring children meet movement behaviour guidelines can positively impact young children’s, particularly boys, social-emotional development, as well as provide a multitude of other health and development benefits. Future research using dose-response evidence is required to identify guideline thresholds for specific health and

development outcomes. This will help inform future updates to the 24-Hour Movement Guidelines for the Early Years to ensure optimal social-emotional development and the overall health and development of young children.

CRedit authorship contribution statement

Hayley Christian: Conceptualization, Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. **Kevin Murray:** Formal analysis, Investigation, Methodology, Writing – review & editing. **Stewart G. Trost:** Data curation, Formal analysis, Funding acquisition, Investigation, Methodology, Writing – review & editing. **Jasper Schipperijn:** Funding acquisition, Investigation, Methodology, Writing – review & editing. **Georgina Trapp:** Funding acquisition, Investigation, Writing – review & editing. **Clover Maitland:** Data curation, Funding acquisition, Investigation, Methodology, Writing – review & editing. **Mark Divitini:** Formal analysis, Investigation, Methodology, Software, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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