



Associations between in-school-hours physical activity and child health-related quality of life: A cross-sectional study in a sample of Australian primary school children

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ABSTRACT

The aim of the current study was to examine the association between Australian primary school children's objectively measured in-school-hours weekly physical activity (PA) and their health-related quality of life (HRQoL). A cross-sectional study of 1128 Grade 2 and 3 children, aged 7–9 years, from 62 primary schools was conducted in New South Wales, Australia between October 2017 and April 2018. Children's PA was assessed via an accelerometer worn for five days during school hours. Their parents completed a telephone interview, answering demographic, child HRQoL and out-of-school-hours PA questions. Children's in-school-hours PA was classified as total PA and moderate-to-vigorous PA (MVPA). HRQoL scores were aggregated and reported at the high construct level domains (Total Quality of Life (Total HRQoL), Physical and Psychosocial Health Summary Scores). Multiple linear mixed regression analyses accounting for clustering were conducted to evaluate the association between children's in-school-hours weekly PA and their HRQoL. After adjusting for potential confounders, significant positive associations were found between children's in-school-hours weekly total PA and Total HRQoL (0.62 units, 95% CI: 0.29; 0.94, $p < 0.001$), Physical (0.71 units, 95% CI: 0.38; 1.04, $p \leq 0.001$) and Psychosocial (0.58 units, 95% CI: 0.19; 0.97, $p = 0.004$) scores, with a stronger association observed between average weekly MVPA than average weekly total PA. There were also positive associations between PA and HRQoL for each sex when analysed separately. Our findings demonstrate a positive association between children's objectively-measured in-school-hours PA and parent-reported child HRQoL, strengthening evidence supporting the continued implementation of school-based PA programs for broader health outcomes.

1. Introduction

Increasing children's physical activity (PA) can help reduce the risk of developing chronic diseases, including type II diabetes, cardiovascular disease and overweight and obesity (Farooq et al., 2020; Telama et al., 2005; Dobbins et al., 2013). The World Health Organization recommends that children aged 5–17 years accumulate at least 60 minutes of moderate-to-vigorous PA (MVPA) each day, half of which is

expected to be achieved during school hours (World Health Organization, 2004). However, studies consistently report that children internationally fail to meet the 60 minute guidelines, with only 30% of primary school aged children reported to participate in adequate daily MVPA (Schranz et al., 2014; Townsend et al., 2015).

The benefit of children meeting PA guidelines may also extend beyond improvements to their physical health (Lubans et al., 2016). Health-related quality of life (HRQoL) is a multidimensional concept

Abbreviations: PA, physical activity; MVPA, moderate-to-vigorous physical activity; HRQoL, health-related quality of life; HNE, Hunter New England; NSW, New South Wales; CATI, computer-assisted telephone interview; SEIFA, Socio-Economic Indexes For Areas

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that incorporates the constructs of physical health as well as psychological and social health, providing a holistic indicator of an individual's overall health (Wallander and Koot, 2016; Motamed-Gorji et al., 2019). Enhancing HRQoL of children is essential for their present and future well-being (Wallander and Koot, 2016), therefore improving children's HRQoL is regarded as a priority area (Cartwright-Hatton et al., 2006). Systematic reviews have found that child PA is positively associated with their HRQoL (Wu et al., 2017; Marker et al., 2018). For example, a 2017 review by Wu et al. (2017) of 31 studies, found that higher levels of PA were associated with higher HRQoL scores in healthy child populations. Similarly, a 2018 review by Marker et al. (2018) of 33 studies, found positive, although small, associations between children's PA and their HRQoL. These reviews included a mixture of studies utilising self and parent-report, as well as objective measures of children's PA. Whilst the findings of these reviews suggest that the association between PA and HRQoL is consistent across the sexes, findings from a recent cross-sectional study of 456 Spanish children aged 11–14 years utilising self-report measures of PA, suggested that there may be differences in these associations by sex Knox and Muros (2017).

Schools are well placed to address the PA and HRQoL of children as they provide access to most children for extensive periods of time (Fox et al., 2004). Furthermore, many schools are mandated, via national or jurisdictional policies, to provide children with a minimum amount of PA per week (NSW Government, 2015; Hardman, 2008; Måsse et al., 2013). Despite this, international studies have found that children's activity levels at school fall below what is recommended, with 8–70% of primary school aged children meeting the recommended 30 mins of daily MVPA guidelines during school hours (Telford et al., 2013; Hubbard et al., 2016; Australian Institute of Family Studies-16, 2015; McCarthy et al., 2018). Furthermore, studies have shown that children who participate in limited PA during school hours, do not compensate by increasing their activity outside of school hours (Dale et al., 2000), thus reinforcing the importance of integrating PA into the school day. Finally, research suggests that there may be important differences in the level of school-based PA performed by males and females, with females spending less time in MVPA (Tanaka et al., 2019). Consequently, there has been an increased focus on implementing strategies that help improve children's engagement in PA at school (Kriemler et al., 2011; Katz, 2009; Langford et al., 2015).

While current school-based PA programs typically address the physical benefits of increased PA, less emphasis has been placed on the possible benefits of such programs on children's HRQoL. In fact, there is a lack of high-quality research that has investigated the association between school-based PA and children's HRQoL. For instance, of the only review that has synthesised studies examining the contribution of school-based PA on HRQoL in healthy child populations (Wu et al., 2017), only two longitudinal studies assessed the impact of school-based PA programs on children's HRQoL (Hartmann et al., 2010; Kriemler et al., 2010). Both studies, which were undertaken with 540 first and fifth Grade Swiss children, found that school-based PA programs had only a small influence on children's HRQoL (Hartmann et al., 2010; Kriemler et al., 2010). Given these were the only two studies, the review authors recommended that further research is required to comprehensively understand the associations between PA, school-based interventions and HRQoL (Wu et al., 2017). Since this review, we are aware of only one other published study (Gu et al., 2020) that examined the association of school-day PA and children's HRQoL. This cross-sectional study, undertaken in four elementary schools, with 374 Hispanic children aged 8–11 years, measured child PA via accelerometers across five days (Gu et al., 2020). After controlling for sex and Grade, they found school-based PA was positively associated with children's HRQoL (Gu et al., 2020). However, the study was only conducted in four U.S. schools, which limits the generalisability of these findings. Furthermore, none of these previous studies have examined the associations between school-based PA and HRQoL for males and females

independently.

While previous studies provide insight into the association between school-based PA and HRQoL, their limitations in terms of population, sample size (Wu et al., 2017) or use of self-report measures impact the reliability and generalisability of their results, particularly to the Australian context. Exploring the association between school-based PA and children's HRQoL will further our understanding of the potential benefits of school PA programs, and may help to extend future programs to address both children's physical and psychosocial outcomes. Furthermore, exploring these associations within male and female children separately will help to determine whether different strategies may need to be considered to optimise the benefits by sex. To address this research gap we aimed to explore the association between Australian primary school children's objectively measured, in-school-hours PA, with their HRQoL. As a secondary aim we sought to explore these associations within males and females separately.

2. Methods

2.1. Ethical approval

Ethical approval was obtained from the Hunter New England (HNE) Human Research Ethics Committee (no. 6/7/26/4.04), the Catholic Schools Office (no. 2012277) and the University of Newcastle Human Research Ethics Committee (no. H-2008-0343).

2.2. Study design and setting

A cross-sectional analysis was employed using baseline data collected from the PACE cluster randomised controlled trial, conducted by Nathan et al. (2019), between October 2017 and December 2018. The study was undertaken with children in Grades 2 and 3, aged between 7 and 9 years, from 62 primary schools in the HNE region of New South Wales (NSW), Australia. The HNE region has a population of approximately 40,847 children aged 5–14 years of age (Australian Bureau of Statistics, 2016).

2.3. Sample and recruitment

All government and Catholic schools in the study region were considered. Schools were ineligible to participate if they were currently participating in another PA intervention, had both primary and secondary children, or catered exclusively for children requiring specialist care (Nathan et al., 2019). School principals were provided with a study information package and asked to provide written informed consent. Following principal consent, parents of children in Grades 2 and 3, were sent an information package outlining the purpose of the study and asked to consent to their child wearing an accelerometer for five days during school time. Consenting parents were invited to complete a computer-assisted telephone interview (CATI) regarding the out-of-school-hours PA behaviours and HRQoL of their child(ren). Child accelerometer and parent CATI data collection were conducted concurrently between October 2017 and April 2018.

2.4. Data collection and measures

2.4.1. Child and parent demographics

Parents were asked to report on their child's sex, age, Grade and postcode via the consent form. The parent CATI included items to assess the demographic characteristics of parents including their: postcode, age, sex, highest educational qualification, employment status, year of birth and main language spoken at home.

2.4.2. Children's in-school-hours physical activity

Children's in-school-hours PA was objectively assessed using a wrist-worn ActiGraph GT3X + or GT9X accelerometer (ActiGraph

Corporation, Pensacola, FL) for five consecutive school days. Accelerometry is valid, reliable and the most widely accepted method of objectively measuring PA in youth (Zheng et al., 2013). Children were asked to wear the accelerometer on their non-dominant wrist (Chandler et al., 2016), from Monday- Friday during school hours (i.e., 9 am–3 pm), with the exception of water-based activities. Children wore their accelerometers as soon as they entered their class for the day and removed at the end of the school day. Child PA data was classified as valid if accelerometers were worn for $\geq 80\%$ of the school day on ≥ 3 days. Accelerometer non-wear time was calculated by summing the number of consecutive zero counts accumulated in strings ≥ 20 minutes. Wear time was estimated by subtracting non-wear time from the total monitoring time for the school day. Child school day PA was classified as MVPA using validated vertical axis wrist cut-points developed by Chandler et al. (2016). Total school day PA was calculated by summing the time spent in light, moderate and vigorous PA. Child school day PA was calculated for descriptive purposes only. When examining the association between in-school-hours PA and HRQoL, PA was measured in hours per school week in order to enhance interpretability of the associations.

2.4.3. Children's out-of-school-hours physical activity

To control for children's usual out-of-school-hours PA, parents were asked, via the CATI, to report on their child's PA behaviours outside of school hours. Six items adapted from the National AusPlay Survey developed by the Australian Sports Commission (2018) were used to ask parents, over the last 7 days, what activities their children participated in outside-of-school-hours and on weekends, for how long they participated in each of these activities and whether the activity was organised or unorganised. PA was defined as participating in any activity inclusive of play, games, sports, transportation e.g., walking or cycling, chores, recreation, physical education, or planned exercise.

2.4.4. Child health-related quality of life

Parent reporting of their children's HRQoL was measured using the Paediatric Quality of Life (PedsQL™) Inventory Version 4.0 via the CATI (Varni et al., 2006). The PedsQL tool is a validated 23-item questionnaire which assesses four domains of children's HRQoL: physical, emotional, social and school functioning (Varni et al., 2006, 2001) (Table 1). The tool has established acceptability, validity and reliability for use with both school children, aged ≥ 8 years old, and parents reporting on their children's behaviours attributing to HRQoL (Varni et al., 2006, 2001). Using a five-point Likert scale (0 = never; 1 = almost never; 2 = sometimes; 3 = almost always; 4 = always), parents reported on their children's physical, emotional, social and school functioning as described in Table 1.

As per guidelines for use of the PedsQL tool by Varni et al. (2006), all responses for HRQoL domain items were reverse coded and converted to a score out of 100 (where 0 = 100; 1 = 75; 2 = 50; 3 = 25; 4 = 0), with a higher item score indicating higher HRQoL (Varni et al., 2006, 2001). Domain scores were then calculated by summing the item responses within each domain and dividing this by the number of items answered in that domain. If an individual was missing $> 50\%$ of items

for a domain, that domain score was not calculated. As per scoring guidelines of the tool, the Psychosocial Health Summary Score was calculated by computing the sum of the items from the Emotional, Social and School Functioning domains over the number of items answered across these domains, and the Physical Health Summary Score consisted of the items from the Physical Functioning domain (Varni et al., 2006, 2001). The Total HRQoL score was generated by combining all items across the four domains. These higher level scores are a standard part of the PedsQL tool. Due to limited research conducted in this area, HRQoL scores were reported at the high construct level (Total HRQoL Score, Physical Health Summary Score and Psychosocial Health Summary Score) to provide an overall representation of higher order physical and psychosocial health contributing to HRQoL in children. These higher order constructs are frequently reported in similar studies (Gu et al., 2020), allowing for interpretation of the results within the broader context of research in this area.

2.5. Statistical analysis

All analyses were performed in SAS version 9.3 (SAS Institute, Cary, North Carolina, USA). Descriptive statistics, including means and standard deviations for continuous data and frequencies and percentages for categorical data, were used to describe child and parent characteristics. Child and parent postcodes were used to categorise their locality as either 'rural' (outer regional, remote and very remote areas) or 'urban' (regional cities and inner regional areas) based upon the Australian Bureau of Statistics (ABS) Australian Standard Geographical Classification system (Australian Bureau of Statistics, 2018). Child and parent postcodes who were ranked in the top 50% of NSW postcodes, based on the ABS Socio-Economic Indexes For Areas (SEIFA), were categorized as 'higher socio-economic areas', while those in the lower 50% were categorized as 'lower socio-economic areas' (Australian Bureau of Statistics, 2016). Child school day PA was reported by intensity and expressed as means and standard deviations for time in each intensity. HRQoL scores were reported as a Total HRQoL score, by Physical and Psychosocial Health Summary Scores, and by each HRQoL subscale domain. Scores were expressed as means and standard deviations for each domain. Linear mixed regressions were used to determine if in-school-hours PA (total PA and MVPA) was associated with HRQoL outcomes. For each HRQoL outcome, linear mixed regressions were used to separately examine the association between in-school-hours PA and HRQoL within each sex. All regression analyses included a random intercept for school to account for the clustered sample, and potential confounders of the association between in-school-hours PA and HRQoL were adjusted for in the regression models, by including them as fixed effects. These confounders included child sex, accelerometer wear time, SEIFA and children's out-of-school-hours PA (Gu et al., 2020). The unadjusted and adjusted regression coefficients and their corresponding 95% confidence intervals (CI) are presented, along with the p-value from the adjusted model. An alpha level of 5% was used to determine a significant association between the PA variables and HRQoL. List wise deletion was used to remove observations with missing data, so that only complete cases were analysed.

Table 1
PedsQL HRQoL domain questions.

HRQoL domain	Number of questions	Characteristics of questions
Physical Functioning	8 questions	Parents were asked to report if their child has difficulty; walking, running, participating in sports activities or exercise, lifting heavy objects, bathing, chores and if their child had low energy or aches.
Emotional Functioning	5 questions	Parents were asked to report if their child has had any feelings of being afraid or scared, sad, angry, is worried about the future and whether their child had trouble sleeping.
Social Functioning	5 questions	Parents were asked to report on their child's friendships, ability to get along with others, if they've been teased about not being able to do what other children can do and whether they keep up with other children.
School Functioning	5 questions	Parents were asked to report whether their child pays attention in class, forgets things, keeps up with school work and misses school because of doctor visits and / or not feeling well.

Table 2
Demographics, school-day PA and HRQoL outcomes for Grade 2 and 3 children (n = 1128).

Demographics for Grade 2 and 3 children	
Category	Total (n)
Total children	<i>n</i> = 1128
Age ^a , (mean) yrs $\pm$ SD	8.11 $\pm$ 0.71
Sex^b, n (%)	
Male	561 (50.04%)
Female	560 (49.96%)
Socio-economic indexes for areas (SEIFA), n (%)	
Most Disadvantaged (Australian Bureau of Statistics, 2016)	545 (48.32%)
Least Disadvantaged (Australian Bureau of Statistics, 2016)	583 (51.68%)
Geographic Location, n (%)	
Major Cities	799 (70.83%)
Inner/Outer Regional/Remote Australia	329 (29.17%)
Physical activity intensity, mean minutes per school day $\pm$ SD (min; max)	
Mean accelerometer wear time	351.20 $\pm$ 18.41
Light Physical Activity (LPA)	114.26 $\pm$ 19.55 (42.33; 181.83)
Moderate-to-Vigorous Physical Activity (MVPA)	38.70 $\pm$ 13.09 (6.58; 100.75)
Total Physical Activity	152.93 $\pm$ 26.72 (54.67; 254.25)
HRQoL domain score^c, mean score $\pm$ SD (min; max)	
Total Quality of Life Score (Total HRQoL Score)	87.34 $\pm$ 10.13 (35.87; 100)
Physical Health Summary Score	91.46 $\pm$ 9.91 (37.50; 100)
Psychosocial Health Summary Score	85.15 $\pm$ 12.23 (23.33; 100)
Emotional Functioning Score	79.93 $\pm$ 17.53 (0; 100)
Social Functioning Score	89.23 $\pm$ 14.28 (5; 100)
School Functioning Score	86.29 $\pm$ 14.03 (15; 100)
Total parents	<i>n</i> = 1092
Age (mean) yrs $\pm$ SD ^a	40.58 $\pm$ 5.85
Socio-Economic Indexes for Areas (SEIFA), n (%)	
Most Disadvantaged (Australian Bureau of Statistics, 2016)	526 (48.25%)
Least Disadvantaged (Australian Bureau of Statistics, 2016)	566 (51.75%)
Geographic Location, n (%)	
Major Cities	772 (70.28%)
Inner/Outer Regional/Remote Australia	320 (29.72%)
Education Level^a, n (%)	
University Degree	498 (45.70%)
No University Degree	591 (54.30%)
Employment^a, n (%)	
Employed	907 (83.33%)
Unemployed	183 (16.67%)
Language Spoken at Home^a, n (%)	
English	1063 (97.48%)
Other	17 (2.52%)

^a There were eighteen children who had missing age data.

^b There were seven children who had missing sex data.

^c There were five children who did not have complete PedsQL HRQoL data.

* There were parents with missing values for these demographics.

3. Results

3.1. Participation and sample characteristics

Originally 172 schools were invited to participate, of which 14 declined and 96 did not reply to the invitation. From the 62 consenting schools, 3439 Grade 2 and 3 children, were asked to participate. Of these, 3299 (96%) had parental consent to wear an accelerometer. There was a significant difference in the sex of consenting children compared to non-consenting children ($p = 0.004$). A higher percentage

of non-consenting children compared to consenting children were female (69% vs. 65%). Overall 3135 children wore an accelerometer (95% of consenting children), of which 2857 (87%) provided valid outcome data, with an average school day wear time of 351.2 min $\pm$ 18.41 (Table 2). For the parent CATI, 2144 parents (85%) consented to participate in the CATI, of which 412 could not be contacted, leaving 1732 (81% of consenters) completing the CATI, and 1092 (51%) providing valid data regarding their child's HRQoL (< 50% of PedsQL domain item responses missing). Parent characteristics are displayed in Table 2.

Overall, 1128 children (34% of consenting children) had both valid accelerometry (at least 3 days wear time at 80% per day) and completed parent-reported PedsQL HRQoL data (Table 2). There were significant differences in the geographic location and socio-economic indexes of children with valid accelerometer and HRQoL data and those without. Specifically, a higher percentage of children with valid data compared to those with invalid data, lived in a 'major city' (71% vs. 59%) ($p = 0.001$) and had a 'least disadvantaged' status (52% vs. 38%) ($p = 0.001$). Of children with valid data and thus included in this analysis, fifty percent were male with a mean age of 8.11 $\pm$ 0.71 years. On average, children spent 44% of their school day (152.93 min $\pm$ 26.72) in total PA, of which 11% (38.70 min $\pm$ 13.09) was spent in MVPA (Table 2). Overall, children had a mean Total HRQoL Score of 87.34 $\pm$ 10.13, a Physical Health Summary Score of 91.46 $\pm$ 9.91 and a Psychosocial Health Summary Score of 85.15 $\pm$ 12.23.

3.2. Associations between in-school-hours weekly total physical activity and HRQoL scores

A positive association was observed between in-school-hours weekly total PA and Total HRQoL scores in children (Table 3). After adjusting for potential confounders, for every hour children spent in total PA during the school week, children's Total HRQoL scores increased by approximately 0.62 units (95% CI: 0.29; 0.94, $p < 0.001$). A positive association was also observed for males and females separately. For males, for every hour spent in total PA across the school week their Total HRQoL score increased on average by 0.91 units (95% CI: 0.44; 1.39, $p \leq 0.001$). For females, for every additional hour of total PA across the school week their Total HRQoL improved on average by 0.49 units (95% CI: 0.02; 0.96, $p = 0.039$).

Overall, significant positive associations were found between in-school-hours of weekly total PA and children's Physical Health Summary Scores, with scores increasing on average by 0.71 units (95% CI: 0.38; 1.04, $p \leq 0.001$) and Psychosocial Health Summary Scores increasing by 0.58 units (95% CI: 0.19; 0.97, $p = 0.004$) in children for every additional hour of total PA per week. For males, for every hour spent in total PA across the school week their Physical Health Summary Score increased on average by 0.77 units (95% CI: 0.30; 1.23, $p = 0.001$) and Psychosocial Health Summary Score increased by 1.00 units (95% CI: 0.43; 1.57, $p \leq 0.001$). Conversely within females, there was only a significant positive association with their Physical Health Summary Scores, (coefficient = 0.66, 95% CI: 0.19; 1.12, $p = 0.006$).

3.3. Associations between in-school-hours weekly MVPA and HRQoL scores

Significant positive associations were identified between in-school-hours weekly MVPA and Total HRQoL scores, with scores increasing on average by 1.02 units (95% CI: 0.33; 1.71, $p = 0.004$) and Physical Health Summary Scores increasing by 1.24 units (95% CI: 0.55; 1.94, $p \leq 0.001$) for all children for each additional hour spent in-school-hours weekly MVPA (Table 3). When analysed separately by males and females, for every additional hour spent in MVPA during school time across the school week, male Total HRQoL scores increased on average by 1.54 units (95% CI: 0.60; 2.47, $p = 0.001$); Physical Health Summary Scores by 1.21 units (95% CI: 0.28; 2.13, $p = 0.011$); and

Table 3

Association between average in-school-hours weekly total PA and MVPA and HRQoL scores in Grade 2 and 3 children (n = 1128).

HRQoL domain score	Sex ^a (n = 1128)	Total physical activity			Moderate-vigorous physical activity		
		Unadjusted β (95% CI)	Adjusted β (95% CI) ^b	p-value	Unadjusted β (95% CI)	Adjusted β (95% CI) ^b	p-value
Total HRQoL Score	Males	0.90 [0.44; 1.36]	0.91 [0.44; 1.39]	< 0.001	1.56 [0.64; 2.48]	1.54 [0.60; 2.47]	0.001
	Females	0.38 [-0.07; 0.83]	0.49 [0.02; 0.96]	0.039	0.60 [-0.47; 1.67]	0.75 [-0.35; 1.85]	0.180
	Total	0.57 [0.25; 0.89]	0.62 [0.29; 0.94]	< 0.001	1.00 [0.32; 1.68]	1.02 [0.33; 1.71]	0.004
Physical Health Summary Score	Males	0.78 [0.33; 1.24]	0.77 [0.30; 1.23]	0.001	1.29 [0.39; 2.20]	1.21 [0.28; 2.13]	0.011
	Females	0.62 [0.18; 1.07]	0.66 [0.19; 1.12]	0.006	1.24 [0.18; 2.29]	1.26 [0.17; 2.35]	0.023
	Total	0.71 [0.39; 1.03]	0.71 [0.38; 1.04]	< 0.001	1.29 [0.61; 1.96]	1.24 [0.55; 1.94]	< 0.001
Psychosocial Health Summary Score	Males	0.98 [0.43; 1.54]	1.00 [0.43; 1.57]	< 0.001	1.75 [0.64; 2.85]	1.74 [0.62; 2.87]	0.002
	Females	0.27 [-0.27; 0.82]	0.41 [-0.15; 0.97]	0.150	0.29 [-1.00; 1.58]	0.50 [-0.83; 1.82]	0.460
	Total	0.52 [0.13; 0.90]	0.58 [0.19; 0.97]	0.004	0.88 [0.06; 1.70]	0.94 [0.11; 1.78]	0.027

Significance set at $p \leq 0.05$. Bolded p-values indicate significance.^a 1128 children were comprised of n = 561 males and n = 560 females. There were seven children who had missing sex data.^b Linear mixed regression analyses was used to calculate β and p-values. β corresponds to the influence of a unit (one hour) increase in PA during school time across a school week on HRQoL scores. Results are listed as estimates with 95% confidence intervals. Analyses included a random intercept for school and were adjusted for child sex, accelerometer wear time, socioeconomic of indexes for areas and out-of-school-hours PA.

Psychosocial Health Summary Scores by 1.74 units (95% CI: 0.62; 2.87, $p = 0.002$). For females, the only statistically significant association identified was between in-school-hours weekly MVPA and Physical Health Summary Scores (coefficient = 1.26, 95% CI: 0.17; 2.35, $p = 0.023$) (Table 3).

4. Discussion

4.1. Study findings within national and global contexts

To our knowledge, this is one of the largest cross-sectional studies conducted globally, that examines the association between primary school children's weekly in-school-hours PA and HRQoL. Additionally, this is the first cross-sectional study within Australia to examine these associations using an objective measure of children's in-school-hours PA. Given current public health priorities aiming to improve children's PA and mental health (Cartwright-Hatton et al., 2006), the findings of this study provide important insights for health promotion research and policy among healthy Australian child populations.

4.2. Association between weekly in-school-hours physical activity and children's HRQoL scores

This study found a positive association between weekly in-school-hours PA and child HRQoL, with a stronger association observed between average weekly MVPA than average weekly total PA. These findings are consistent with previous cross-sectional studies conducted in the USA and Malaysia (Gu et al., 2020; Kattelmann et al., 2018; Wafa et al., 2016), which have also found a positive association between children's accelerometer-measured MVPA and their HRQoL. These findings, together with the current study support the growing body of research illustrating the potential psychosocial benefits of PA in children, particularly MVPA. Although, the cross-sectional nature of these studies do not allow for conclusions to be drawn regarding the direction, or the causal nature of this association; other longitudinal and experimental studies in Australian adolescent and Dutch child populations have shown that increasing PA and participation in highly active sports over the long term leads to increases in HRQoL (Gopinath et al., 2012; Moeijes et al., 2019), supporting this hypothesis. Together this research helps to further support recommendations for the implementation of school-based PA interventions to address both children's PA and HRQoL (Van Kann et al., 2016; Seljebotn et al., 2018). We recommend that future longitudinal and experimental studies are conducted in school children to help further improve the evidence in

this area, and confirm this hypothesis.

4.3. Associations between weekly in-school-hours physical activity and children's HRQoL scores by sex separately

When analysed separately by sex, there was a significant positive association between in-school-hours weekly total PA and Total HRQoL scores for both males and females. Again, this association was consistently stronger for MVPA. Interestingly, males possessed a significant positive association between time in both in-school-hours weekly total PA and MVPA and Total HRQoL, Physical and Psychosocial Health Summary Scores. Comparatively, in-school-hours weekly PA for females was only positively related to Total HRQoL and Physical Health Summary Scores. Previous findings by Gu et al. (2016) and Knox and Muros (2017) demonstrated that on average, males were more active, in terms of intensity and duration of PA than females. This may potentially explain the stronger within-group associations between in-school-hours weekly total PA and HRQoL in males within the current study, particularly when examining time in MVPA. Converse to the current study's findings, a cross-sectional study conducted in a sample of Spanish primary school children by Knox and Muros (2017), found that in female primary school children, PA positively predicted physical and psychological wellbeing. However for males, PA only predicted positive physical wellbeing. However, this study employed a self-report measure for PA and a child-self report measure for HRQoL (Knox and Muros, 2017). Differences in PA and HRQoL measurement may partially explain some of the inconsistencies in findings. Given the limited research examining within-group associations between in-school-hours PA and child HRQoL, future studies should examine the differential effects by sex, which was not done in this study due to the exploratory nature of this investigation.

5. Limitations

There are limitations that should be considered when interpreting the results of this study. First, as this is a cross-sectional design, causation and temporality cannot be inferred. Thus, additional longitudinal and experimental studies are required to assess the casual association between child in-school-hours PA and HRQoL. Second, whilst the sample size is large, there was a large reduction in sample size, with significant differences found in the geographic location and socio-economic indexes of children with valid accelerometer and HRQoL data and those without, resulting in a potentially biased sample. Within the current study only in-school-hours PA was objectively monitored. To

more accurately account for children's out-of-school-hours PA levels the use of 24 hr wear time for accelerometry over a seven day period is recommended. Finally, whilst parent-reporting of child HRQoL is validated, a child self-report measure, would provide a more accurate measure of subjective HRQoL.

6. Conclusion

Ultimately the findings from this study provide a greater understanding of the association between in-school-hours PA across the school week and HRQoL in Australian primary school children. Given the positive association found between children's in-school-hours weekly PA and their HRQoL, these findings suggest that supporting schools to implement PA policies and programs may provide benefits to children extending beyond their physical health.

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CRediT authorship contribution statement

Adam Shoesmith: Conceptualization, Formal analysis, Investigation, Methodology, Project administration, Resources, Validation, Visualization, Writing - original draft, Writing - review & editing. **Alix Hall:** Formal analysis, Supervision, Methodology, Validation, Writing - review & editing. **Kirsty Hope:** Conceptualization, Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Writing - original draft, Writing - review & editing. **Rachel Sutherland:** Writing - review & editing. **Rebecca K. Hodder:** Investigation, Methodology, Writing - original draft, Writing - review & editing. **Stewart G. Trost:** Methodology, Data curation, Software, Formal analysis, Writing - review & editing. **Christophe Lecathelinais:** Data curation, Software, Formal analysis, Writing - review & editing. **Cassandra Lane:** Conceptualization, Methodology, Writing - review & editing. **Nicole McCarthy:** Conceptualization, Methodology, Writing - review & editing. **Nicole Nathan:** Conceptualization, Investigation, Methodology, Project administration, Supervision, Validation, Visualization, Writing - original draft, 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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