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Screen time and physical activity behaviours are associated with health-related quality of life in Australian adolescents

Authors

Kathleen E. Lacy PhD¹, Steven E. Allender PhD^{1, 2}, Peter J. Kremer PhD³, Andrea M. de Silva-Sanigorski PhD^{1, 4}, Lynne M. Millar BA (Psych Hons)¹, Marjory L. Moodie DrPH⁵, Louise B. Mathews MA⁶, Mary Malakellis MSc¹, Boyd A. Swinburn MBChB, MD, FRACP¹

Author affiliations and addresses

¹WHO Collaborating Centre for Obesity Prevention, Geelong Waterfront Campus, Deakin University, Geelong, Victoria 3217, Australia

²Department of Public Health, University of Oxford, Oxford, United Kingdom

³School of Psychology, Geelong Waterfront Campus, Deakin University, Geelong, Victoria 3217, Australia

⁴Melbourne School of Population Health, Level 5, 207 Bouverie Street, The University of Melbourne, Victoria 3010, Australia

⁵Deakin Health Economics Unit, Melbourne Campus at Burwood, Deakin University, 221 Burwood Highway, Burwood, Victoria 3125, Australia

⁶School of Education, Geelong Campus at Waurin Ponds, Deakin University, Pigdons Road, Geelong Victoria 3217, Australia

Contact for correspondence

Kathleen E. Lacy, PhD

Email: katie.lacy@deakin.edu.au, Telephone: +61 3 5227 8483, Fax: +61 3 5227 8376

Manuscript details

Word count: 5,102 Abstract word count: 211, Tables: 5, Figures: 1

ABSTRACT

Purpose

To explore the cross-sectional relationships between health-related quality of life (HRQoL) and physical activity (PA) behaviours and screen-based media (SBM) use among a sample of Australian adolescents

Methods

Data came from baseline measures collected for the *It's Your Move!* community-based obesity prevention intervention. Questionnaire data on sociodemographics, PA, SBM and HRQoL data were collected from 3,040 students (56% male) aged 11-18 years in grade levels 7-11 in 12 secondary schools. Anthropometric data were measured.

Results

The highest level of PA at recess, lunchtime and after school was associated with higher HRQoL scores (males, by 5.3, 8.1, 6.3 points; females, by 4.2, 6.1, 8.2 points) compared with not being active during these periods. Exceeding two hours of SBM use each day was associated with significantly lower HRQoL scores (males, by 3.2 points; females, by 4.0 points). Adolescents who were physically active and low SBM users on school days had

higher HRQoL scores (males, by 6.6 points; females, by 7.8 points) compared with those who were not physically active every school day and high SBM users on school days.

Conclusions

Several of the relationships between low PA and high SBM use and HRQoL were comparable to those previously observed between chronic disease conditions and HRQoL, indicating that these behaviours deserve substantial attention.

INTRODUCTION

Health-related quality of life (HRQoL) is a measure of the physical and psychosocial dimensions of health [1] and an important health outcome [2; 3]. Low levels of HRQoL are associated with chronic conditions [4; 5] and diseases, including cancer [5], hypertension [6] and diabetes [7]. Previous work has quantified the impact of specific illnesses and examined potential strategies to improve HRQoL [8; 9]. For example, Speyer et al. [8] found that participation in adapted physical activity during hospital stays increased HRQoL among children and adolescents with cancer.

Adolescence is marked by considerable physical, psychological and social changes affecting HRQoL [10]. Recent research aims to test strategies to improve HRQoL among the general population such as increased physical activity (PA) [11], though data on HRQoL from PA interventions are scarce [11]. Higher levels of PA have been shown to be consistently associated with elevated HRQoL scores among healthy adults [11-13] suggesting that increasing PA may be an effective strategy for improving HRQoL.

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75 While the relationship between PA and HRQoL is well established in the general
76 adult population, there is limited evidence for this relationship among children [14] or
77 adolescents, particularly Australian adolescents. Studies among adolescents have tended to
78 focus on the relationships between PA (moderate to vigorous or general PA) and specific
79 aspects of HRQoL [15-18], such as psychological [19] and emotional wellbeing [20], rather
80 than assessing both physical and psychosocial dimensions of health.

81

82 Even less is known about the relationship between HRQoL and sedentary behaviours
83 such as screen-based media use (SBM; watching television, playing video games or using the
84 computer for non-educational purposes) among adolescents despite SBM constituting a large
85 proportion of leisure time use among this group [21-23]. Adolescent SBM use has been
86 shown to have clear associations with health outcomes such as obesity [21; 22; 24] and
87 psychological wellbeing [19]. Eisenmann et al. [22] showed that compared with those who
88 reported watching four or more hours of TV per day, adolescents were 20% to 25% less
89 likely to be classified as overweight if they reported watching two to three hours of TV per
90 day and 40% less likely if they watched an hour or less per day. Ussher et al. [19] found that
91 increased use of TV, videos and computers was associated with lower psychological
92 wellbeing among adolescents. PA and SBM are important but different behaviours, and SBM
93 use does not necessarily replace PA among adolescents [16], and each is likely to have
94 independent effects on HRQoL.

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96 Increased PA and reduced SBM use may be effective in improving HRQoL among
97 adolescents, though little is known about the relationships between HRQoL and PA and SBM
98 use among Australian adolescents. The Australian Government recommends that adolescents

participate in at least 60 minutes of moderate to vigorous PA each day (may be accumulated throughout the day) and should spend no more than two hours per day watching TV, playing video games and using the computer for non-educational purposes [25]. The aim of this study was to examine cross-sectional relationships between health-related quality of life and physical activity behaviours and screen-based media use among a sample of Australian adolescents.

METHODS

Design

Data presented here are baseline measures from the *It's Your Move!* (IYM) obesity prevention intervention conducted among secondary school students in the Barwon-South Western region of Victoria, Australia. IYM had a quasi-experimental design and details of the study have previously been reported [26; 27]. IYM aimed to increase community capacity to promote healthy eating and PA and to prevent unhealthy weight gain in adolescents. Baseline data were collected throughout 2005-06 from adolescents who provided both verbal consent and written parental consent. The project had ethics approval from the Deakin University Research Ethics Committee (EC 22-2005) and educational institutions for government, Catholic and independent schools and was registered as a trial (ACTR # EC 37-2004).

Participants

Students from 12 secondary schools in the Barwon-South Western region of Victoria were invited to participate in the study. All 6,013 students in grade levels 7-11 attending the 12 selected schools were invited to participate in baseline data collection and 3,040 consented and were subsequently included (response rate of 51.0%).

Measures

Sociodemographic and other characteristics

Participants self-reported their date of birth, grade level and ethnicity using an 84-question Adolescent Behaviours, Attitudes and Knowledge Questionnaire [28; 29]. This questionnaire also contained items about PA patterns, sedentary behaviours, nutrition/dietary practices and perceptions of school, home and neighbourhood environments. The questionnaire took approximately 15-20 minutes to complete, and participants completed it in their classroom using personal digital assistants (PDAs; hand-held mobile devices used to manage personal information; Hewlett Packard iPAC Pocket PC).

Participants' postcodes were used to identify the relative socio-economic advantage or disadvantage for the geographical areas in which they lived. This was accomplished using the Socio-Economic Indexes for Areas (SEIFA), which rank geographical areas across Australia in terms of their socio-economic characteristics based on data collected via the Australian Census of Population and Housing [30]. Relative advantage is associated with a higher SEIFA score, which indicates that an area has a relatively large proportion of people with high incomes or a skilled workforce [30]. SEIFA scores were categorised into socio-economic status quartiles based on the population distribution in the state of Victoria.

Physical activity and sedentary behaviours

Participants self-reported their PA and sedentary behaviours as part of the questionnaire. Specifically, PA behaviours during school recess and lunchtime and after school on the five school days prior to the survey date were assessed using three questions. For the two questions about breaks during the school day, students reported whether they

were mostly sedentary ('mostly just sat down'), did minimal PA ('mostly stood or walked around') or were mostly physically active ('mostly played active games'). The question about after-school PA asked about the number of days adolescents participated in active sports, dance, cultural performances or games. These three questions were adapted from the 2002 National Children's Nutrition Survey conducted in New Zealand [29; 31]. An indicator combining all three reported school-day PA behaviours was developed using the three questions about school-day PA behaviours. For this indicator, adolescents were classified into one of two categories: physically active at least once every school day or not physically active at least once every school day. Those who 'mostly played active games' during at least one school break (recess or lunchtime) or who participated in PA after school on all five school days were considered physically active on every school day. Those who 'mostly just sat down' or 'mostly stood or walked around' at recess and lunchtime and participated in PA after school on four or fewer days were not considered physically active on every school day.

Leisure time screen-based behaviours were assessed using eight questions, four of which related to television viewing (including videos and DVDs) and four to playing video games and using the computer (other than for homework). These eight questions were adapted from the 2002 National Children's Nutrition Survey conducted in New Zealand [29; 31] and asked about television viewing or video game and computer use on the last five school days and on the previous Saturday and Sunday. Participants' responses were used to calculate averages of the number of hours spent daily watching television and the number of hours spent daily playing video games and using the computer (other than for homework). These averages were combined to calculate a composite measure of the average amount of leisure time spent daily in front of a screen. This average was then categorised according to

whether it met (≤ 2 hours/day) or exceeded (> 2 hours/day) the guideline recommended by the Australian Government [25].

An indicator combining school-day PA behaviours and school-day SBM use was developed. Participants' responses to the questions that asked about television viewing or video game and computer use on the last five school days were used to calculate averages of the number of hours spent daily watching television and the number of hours spent daily playing video games and using the computer (other than for homework) on school days. These averages were combined to calculate a composite measure of the average amount of school-day leisure time spent daily in front of a screen. Adolescents whose average school-day leisure time SBM use met (≤ 2 hours/day) the guideline recommended by the Australian Government [25] were considered low users of media on school days and those whose average exceeded (> 2 hours/day) the guideline [25] were considered high users of media on school days. This measure was combined with the indicator combining all three school-day PA behaviours (described above) and adolescents were then classified into one of four categories: not physically active every school day/high screen-based media users, physically active every school day/high screen-based media users, not physically active every school day/low screen-based media users or physically active every school day/low screen-based media users.

Health-related quality of life

Participants self-reported HRQoL by completing the adolescent module of the Pediatric Quality of Life Inventory 4.0 Generic Core Scales (PedsQLTM 4.0) [32; 33] using PDAs. The PedsQLTM 4.0, developed by Dr. James W. Varni, has been recommended as appropriate for use in clinical trials, research, clinical practice, school health settings and

community populations [33], and the reliability and validity of this instrument have previously been reported [33; 34]. The suitability of PDAs as instruments for collection of PedsQL™ 4.0 information was assessed through pilot testing with 95 adolescents and was subsequently found to be a valid method. The PedsQL™ 4.0 consists of 23 items across four domains: physical, emotional, social and school functioning. The PedsQL™ 4.0 was scored in accordance with guidelines for its use [2; 33]. Specifically, items were reverse-scored and linearly transformed to a 0 to 100 scale so that higher scores indicated better HRQoL. A total score was calculated using the mean of all 23 items.

Anthropometry

Participants were weighed and measured by trained research staff using standardized protocols in accordance with customary methods for anthropometric data collection in children [35]. Participants wore light clothing and did not wear shoes. Body weight was measured to the nearest 0.1 kg using a TANITA Body Composition Analyser (Model BC418). Height was measured to the nearest 0.1 cm using a portable stadiometer (Surgical and Medical PE87). Body mass index (BMI) was calculated using the WHO reference 2007 Stata module, and weight status was defined using the WHO age-specific BMI cut-offs [36].

Statistical analysis

Data were analysed using Stata, version 11.0 (StataCorp LP, College Station, Texas, USA). Results were considered statistically significant at $p < 0.05$ and reported as mean $\pm$ standard deviation (SD). Where data were non-normally distributed, non-parametric analyses were performed and medians with interquartile ranges (IQR) reported.

Descriptive statistics were calculated for the total sample and male and female subgroups. Differences between males and females in terms of age, BMI, weight status, grade level, area socio-economic status (SES) quartile, PA and sedentary behaviours, and PedsQL scores were examined using two-sided *t*-tests, Pearson Chi-square tests or Wilcoxon rank-sum tests, as appropriate.

The primary outcome of the study was PedsQL total score. Separate one-way analysis of variance (ANOVA) tests and two-sided *t*-tests were used to assess differences between PedsQL total scores across the levels of each of the PA and sedentary behaviours. Linear regression analyses were used to measure the associations between each of the PA and sedentary behaviours and total score for male and female adolescents. The Stata interaction expansion command was used to specifically calculate the regression estimates for individual categories of independent categorical variables based on the first category for each variable. Regression models were adjusted for clustering by school and controlled for the potential confounder weight status [5]. Area SES and grade level (proxy for age) were also tested as potential confounders.

Supplementary analyses were conducted to investigate potential differences in PedsQL total score according to age as there is some indication that HRQoL decreases with age among adolescents [10]. Adolescents were classified into one of two age groups (under 15 years of age or 15 years of age or older) and all analyses were stratified by age group. Differences between younger and older adolescents in terms of PedsQL total scores and PA and sedentary behaviours were examined using Pearson Chi-square tests or Wilcoxon rank-sum tests, as appropriate. Separate one-way analysis of variance (ANOVA) tests and two-

sided *t*-tests were used to assess differences between PedsQL total scores across the levels of each of the PA and sedentary behaviours.

RESULTS

Participant characteristics

The mean age ($\pm$ SD) of participants was 14.6 ± 1.4 years (range: 11.4 - 18.3 years). The students were evenly distributed between grade levels seven, eight and nine with smaller proportions in grade levels ten and eleven (Table 1). Most students identified as Australian European and more than half were classified into the higher area SES quartiles (Table 1). The sample had a mean BMI of 21.8 ± 3.8 (range: 14.0 - 42.8); 68% were classified as healthy weigh and 32% were overweight or obese using WHO [36] definitions (Table 1).

Physical activity and sedentary behaviours

More than half of adolescents either stood or walked around (56%) or played active games (26%) during morning recess. At lunchtime, 51% stood or walked around and 33% played active games. Compared with females, males reported more active play during both recess and lunchtime (Table 2). More than half of adolescents were physically active after school on two (21%), three (24%) or more (32%) days per week. Physical activity patterns after school were similar across sexes (Table 2) except that a larger proportion of males was physically active on every day after school compared with females. A large minority (43%) of adolescents was physically active at least once on every school day. A larger proportion of males was physically active on every school day compared with their female counterparts (Table 2).

The median for the composite measure of SBM use per day was 1.71 hours (IQR: 0.86 – 3.14), with median hours per day spent watching TV, videos and DVDs 1.14 (IQR: 0.57 – 2.14) and median hours per day playing video games or using the computer 0.36 (IQR: 0.07 – 1.00). While more than half of adolescents (57%) spent an average of two hours or less of leisure time per day in front of a screen, fewer males than females met the Australian Government's current screen time recommendation [25] (Table 2).

About a fifth (21%) of adolescents was classified as not physically active on every school day and high users of SBM on school days. More than a quarter (28%) were classified as physically active every school day/low SBM users on school days and more than a third (36%) were classified as not physically active every school day/low SBM users. The patterns of classification into these groups differed between males and females (Table 2).

PedsQL scores

Compared with females, males had significantly higher PedsQL total scores (79.2 ± 11.1 vs. 77.1 ± 11.7 ; $p < 0.001$). As a result of this difference, the remainder of the analyses was stratified by sex. Within the male and female subgroups, there were no significant differences in PedsQL total scores for adolescents from different school grade levels or different area SES quartiles. Those classified as overweight or obese had significantly lower total scores compared with those of healthy weight among both males (78.1 ± 12.0 vs. 79.7 ± 10.7 ; $p < 0.01$) and females (75.1 ± 12.6 vs. 78.0 ± 11.1 ; $p < 0.001$).

PedsQL scores by physical activity and sedentary behaviours

Among males and females, there were significant differences in total scores of the PedsQL for different levels of PA at morning recess, lunchtime and after school (a, b and c in

Figure 1). Higher PedsQL total scores were associated with higher levels of PA during each of these time periods measured in both sexes. Among males and females, PedsQL total scores were significantly higher for those who were classified as physically active at least once every school day compared with those who were classified as not physically active at least once every school day (d in Figure 1). PedsQL total scores for both males and females were significantly higher for those who spent two hours or less of leisure time per day in front of a screen compared with those who spent more than two hours per day in front of a screen (e in Figure 1). Among both males and females, there were significant differences in PedsQL total scores for different classifications based on both school-day PA and school-day SBM use (f in Figure 1).

Crude regression models generally showed positive associations between PA behaviours during the school week and PedsQL total scores (Table 3). Higher levels of PA behaviours were associated with higher total scores. Among males, the highest level of activity at recess, lunchtime and after school was associated with PedsQL total scores that were significantly higher by 5.28, 8.10 and 6.32 points compared with their least active male counterparts. Females who were most physically active at recess, lunchtime or on every day after school had total scores that were significantly higher by 4.20, 6.11 and 8.23 points compared with their least active female counterparts. For both males and females, participation in PA after school on only one day of the week was not associated with a higher PedsQL total score compared with not participating in PA after school, but participation in PA after school on two or more days of the week was associated with a higher PedsQL total score (Table 3). Being physically active at least once per school day (during recess, lunchtime or after school) was also associated with higher PedsQL total scores among males and females compared with not being active at least once per school day (Table 3).

Crude regression models generally showed negative associations between SBM use and PedsQL total scores (Table 3). An increase of one hour per day in average screen time per day was associated with PedsQL total scores that were significantly lower by 1.26 and 1.82 points among males and females, respectively. Exceeding the Australian Government's screen time recommendation was associated with PedsQL total scores that were significantly lower by 3.17 and 4.01 points among males and females, respectively.

Crude regression models also showed that being physically active at least once per day or being a low user of SBM on school days was associated with higher PedsQL total scores among both males and females (Table 3). Participating in physical activity at least once a day and being a low user of SBM was associated with PedsQL total scores that were significantly higher by 6.56 and 7.76 points compared with not participating in physical activity at least once a day and being a high user of SBM for males and females, respectively.

The adjusted regression models were controlled for weight status because PedsQL total scores differed by weight status classification. Adjustment of the crude models did not appreciably affect the observed associations, as changes to point estimates were minimal (Table 3). Adding area SES quartile and grade level to the adjusted models did not substantially change the observed associations, so these variables were not included in the final models.

Age subgroup analyses

The subgroup of adolescents under 15 years of age comprised 1,829 adolescents and the subgroup of adolescents 15 years of age or older included 1,211 adolescents. There was

no significant difference in PedsQL total score by age group. The mean ($\pm$ SD) PedsQL total score for younger adolescents was 78.3 ± 11.8 and that for older adolescents was 78.2 ± 10.8 . Younger and older adolescents had significantly different patterns of PA behaviour at recess and lunchtime but did not differ in patterns of after-school PA (Table 4). Compared with their older peers, a larger proportion of younger adolescents was physically active at least once every school day and younger adolescents also spent more time playing video games or using the computer (not for homework) (Table 4). More than a quarter (30%) of younger adolescents was classified as physically active every school day/low SBM users on school days, and a quarter (25%) of older adolescents was classified into this group. The patterns of classification into groups based on both school-day PA and SBM use differed between younger and older adolescents (Table 4).

Associations between PedsQL total score and PA and SBM use behaviours were similar in both younger and older adolescents (Table 5). Among both younger and older adolescents, there were significant differences in PedsQL total scores for different levels of PA at morning recess, lunchtime and after school (Table 5). Higher PedsQL total scores were associated with higher levels of PA during each of these time periods for both groups. PedsQL total scores were significantly higher for those who were classified as physically active at least once every school day compared with those who were classified as not physically active at least once every school day (Table 5). PedsQL total scores were significantly higher for those who spent two hours or less of leisure time per day in front of a screen compared with those who spent more than two hours per day in front of a screen (Table 5). There were significant differences in PedsQL total scores for different classifications based on both school-day PA and SBM use (Table 5).

DISCUSSION

This study investigated relationships between physical activity behaviours and leisure time screen-based media use and health-related quality of life among a sample of Australian adolescents. Participation in physical activity during the school day and in after-school physical activity were found to be associated with higher health-related quality of life. Time spent using screen-based media was inversely associated with health-related quality of life. These relationships were consistent for both males and females and did not alter after adjusting for weight status.

The observed associations between PA and HRQoL among adolescents replicate those reported in cross-sectional studies among adults [11-13]. There are few studies of PA and HRQoL among adolescents and those that do exist generally focused on populations with identified disease conditions, making comparison with these results difficult. Shoup and Dandamudi [14] explored the relationship between PA and HRQoL in overweight 8- to 12-year-old children in the US and found that meeting the recommended guideline for PA (60 minutes or more each day [37]) was associated with higher HRQoL. However, overweight children and adolescents may have different HRQoL profiles compared with their healthy weight peers [5]. Recently, Boyle et al. [38] examined the relationship between HRQoL and PA among 11- to 15-year-old adolescents in the UK and found no differences in HRQoL between adolescents who achieved 60 minutes of PA per day and those who did not. One potential explanation given by Boyle et al. [38] for this result is that survey respondents (33% response rate) were more likely to be motivated students with higher levels of HRQoL. The present study builds upon this previous research. Demonstrating a positive relationship between PA and HRQoL in female adolescents is particularly important as females tend to be less physically active than males during adolescence [39] and may have impaired

psychological well-being during this time [40]. Increasing PA among females could potentially benefit this group by both helping them to meet PA recommendations and to improve psychological health.

The present study showed that being physically active on at least two nights per week was associated with higher HRQoL compared with being inactive after school. This result was supported by the other findings from the present study demonstrating that those participating in minimal activity (mostly standing or walking around) during school recess and lunchtime had higher HRQoL compared with those who were sedentary during these school breaks. These findings should be interpreted with caution both because the cross-sectional data presented in this study cannot establish a causal relationship and because the data were limited to specific school-day PA behaviours. Furthermore, Hallal et al. [41] found that the benefit threshold for adolescent PA varies with the health condition being studied so the current recommendations for ‘healthy’ levels of PA among adolescents, participation in PA on a daily basis, are appropriate [25].

The other main finding of this study, observed inverse associations between leisure time SBM use and HRQoL among Australian adolescents, is novel. This finding is supported by previous studies demonstrating SBM use among adolescents to be inversely associated with outcomes related to HRQoL, such as life satisfaction [15; 16], physical health status [15] and psychological wellbeing [19; 42]. Iannotti et al. [15] found that SBM use was associated with perceptions of poorer physical health and life satisfaction among samples of adolescents from the US and Canada. The authors suggested that one potential explanation for this finding is that time spent watching television may replace time spent engaging in social activities, resolving personal problems or testing one’s cognitive and physical capacities [15].

An alternative hypothesis is that media content could impact on psychosocial health. For instance, watching violent programs could lead to fear, anxiety and antisocial behaviour, and exposure to unrealistic ideals of female beauty and male muscularity could lead to emotional distress [43].

The present study demonstrated that despite being classified as high SBM users, adolescents who were also classified as physically active at least once every school day had PedsQL total scores that were significantly higher than those of adolescents classified as both high SBM users and not physically active every school day. Similar results were observed among adolescents classified as not physically active every school day/low SBM users. The relationships between PA and sedentary behaviours, such as SBM use, among adolescents are not straightforward [16; 24] and associations between PA, SBM use and health correlates are even less well-understood [42; 44]. Page et al. [42] reported that 10- to 11-year-old children who met physical activity guidelines yet exceeded SBM use guidelines were at increased risk of psychological distress. Iannotti et al. [16] have suggested that inactivity in itself is unlikely to be the mechanism underlying the relationship between psychological and social health and SBM use due to observed associations between adolescent psychological and social health and PA not mirroring those between psychological and social health and SBM use. If PA and SBM use are indeed independent behaviours with separate associations with health outcomes, then it is important to promote modification of both types of behaviour among adolescents.

Varni et al. [45] compared HRQoL across ten pediatric chronic disease areas as measured by the PedsQLTM 4.0. A number of the HRQoL differences between adolescents with highest levels of PA and those with lowest levels of PA observed in the present study exceeded HRQoL differences reported by Varni et al. [45] between healthy children and

adolescents and those with chronic conditions. For example, the HRQoL differences between adolescents who mostly played games at lunchtime and those who were sedentary and the differences between adolescents who participated in after-school PA on five days and those who reported no days of after-school PA were greater than the quality of life losses reported by Varni et al. [45] for diabetes (3.49 points) and gastrointestinal conditions (6.05 points). Additionally, the HRQoL reductions associated with school-day physical inactivity and high SBM use (6.56 and 7.76 points for males and females, respectively) detected in the present study exceeded the quality of life losses reported by Varni et al. [45] for cardiac diseases (6.37 points).

The use of self-reported and cross-sectional measures of PA was a limitation of this study. Self-report is prone to social desirability and recall issues and causal relationships cannot be discerned from cross-sectional data. In this study, for example, it is possible that poorer HRQoL leads to lower levels of PA and greater SBM use rather than the other way around. It is also possible that these factors are related to a third unmeasured factor. Another limitation was that the study focused on select PA behaviours only on school days and did not consider participation in physical education classes or PA behaviours on weekends.

The practical implications of the present study warrant further exploration. Approximately one fifth of male and one quarter of female adolescents were either inactive after school or participated in after-school PA on only one night per week, revealing a potential need to increase efforts to promote after-school PA among adolescents. School recess and lunchtime breaks offer opportunities for students to engage in PA that can help them to accumulate 60 minutes of moderate to vigorous PA on school days, but fewer than half of the adolescents in the present study reported playing active games during these breaks.

Perhaps schools should provide greater encouragement for adolescents to be physically active during breaks by making better facilities and equipment available. Schools may need to focus particularly on females as their participation in active games during breaks was especially low in the present study. The Australian Government recommends that adolescents spend no more than two hours using SBM daily during leisure time [25]. Findings from the present study demonstrated that meeting this recommendation was associated with higher HRQoL, so this recommendation may be appropriate for supporting adolescent HRQoL. Parents may need to monitor and limit adolescent leisure time SBM use, but little is known about how best to do this and what effect it has on SBM use [46].

This cross-sectional analysis could not be used to establish a dose-response relationship between PA and HRQoL. Brown et al. [13] suggest the relationship may not be straightforward. Future research should investigate whether a dose-response relationship exists between PA and HRQoL among adolescents.

The analyses presented in this study represent an initial exploratory step towards establishing whether increasing PA levels and decreasing SBM use are effective strategies for improving HRQoL among adolescents. The results of the present study support the pursuit of continued research in this area. Future studies should investigate the longitudinal relationships between HRQoL and PA and SBM use among adolescents. Studies should also examine synergistic effects of low PA and high SBM use. Further, understanding whether adolescents think PA is important and determining how to change adolescent behaviour are also of great interest.

Conclusions

495 The positive relationships observed between HRQoL and PA behaviours are
496 consistent with those found among adults. The inverse relationships found between HRQoL
497 and SBM use are novel and important findings considering adolescents spend a significant
498 amount of time using SBM. Some of the relationships between low PA and high SBM use
499 and HRQoL were comparable to those previously observed between chronic disease
500 conditions and HRQoL, indicating that these behaviours deserve considerable attention.
501 Additional research is needed to understand the long-term impacts on HRQoL of PA and
502 SBM use and to determine whether increasing PA, limiting SBM use or combining both
503 behaviours will be effective strategies for enhancing adolescent HRQoL.

FIGURE 1 CAPTION

PedsQL total scores by PA and sedentary behaviours of adolescents (means and 95% confidence intervals)

*Analyses stratified by sex; PedsQL total scores significantly different for males (dark grey, $p<0.001$) and females (light grey, $p<0.01$)

†Analyses stratified by sex; PedsQL total scores significantly different for males (dark grey, $p<0.001$) and females (light grey, $p<0.001$)

512 **ACKNOWLEDGEMENTS**

513 This project was funded by the Victorian Department of Human Services as part of
514 the Victorian ‘Go for your life’ Healthy Eating and Physical Activity initiative, in
515 conjunction with VicHealth and the National Health and Medical Research Council.

516 We wish to acknowledge the principals, teachers, students and School Project
517 Officers (Sue Blackett, Lee Denny, Kerry Fearnside, Chris Green, Sonia Kinsey, Kirsty
518 Licheni, Kate Meadows, Lauren Reading and Lyndal Taylor) from the 12 schools involved in
519 the project. Acknowledged also are Colin Bell and others from the ‘Support and Evaluation
520 Team’, Anthony Bernardi, Phil Day, Lawrence Meade, Lily Meloni and Narelle Robertson
521 from the WHO Collaborating Centre for Obesity Prevention, Deakin University.

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FIGURE 1

Table 1. Characteristics of adolescents

Characteristic		Male, 1,706 (56%)	Female, 1,334 (44%)	P*
Age (years)	Mean ± SD	14.6±1.3	14.7±1.4	NS
	(95% CI)	(14.5, 14.7)	(14.6, 14.7)	
	Range	11.4-18.3	11.8-18.1	
Body Mass Index (BMI)	Mean ± SD	21.6±3.7	22.0±3.9	<0.01
	(95% CI)	(21.4, 21.8)	(21.8, 22.2)	
	Range	14.3-41.3	14.0-42.8	
Weight Status	Thinness, n (%)	8 (<1)	11 (<1)	NS
	Normal Weight, n (%)	1,145 (68)	887 (68)	
	Overweight, n (%)	358 (21)	302 (23)	
	Obesity, n (%)	175 (10)	112 (9)	
	Missing, n	20	22	
Grade Level	7 (~13 years of age), n (%)	441 (26)	351 (27)	<0.05
	8 (~14 years of age), n (%)	401 (24)	281 (21)	
	9 (~15 years of age), n (%)	392 (23)	277 (21)	
	10 (~16 years of age), n (%)	298 (18)	249 (19)	
	11 (~17 years of age), n (%)	149 (9)	159 (12)	
	Missing, n	25	17	

Area SES	<25 th n, (%)	427 (25)	333 (25)	<0.05
	25 th to <50 th n, (%)	257 (15)	225 (17)	
	50 th to <75 th n, (%)	682 (40)	562 (43)	
	≥75 th n, (%)	322 (19)	192 (15)	
	Missing, n	18	22	
SD, standard deviation 95% CI, 95% confidence interval Body Mass Index = body weight (kg)/ height (m) ² Weight Status defined according to WHO cut points [36] Area SES, socio-economic status of area measured by SEIFA [30] and categorised into quartiles based on the population distribution in the state of Victoria P*, Difference between means for males and females tested using <i>t</i> -test or equality of distributions for males and females tested using Pearson Chi-square test, as appropriate Percentages may not equal 100 due to rounding				

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Table 2. Physical activity and sedentary behaviours of adolescents				
	Behaviour	Male	Female	P*
Main physical activity at morning recess in last 5 school days	Mostly just sat down, n (%)	195 (12)	357 (27)	<0.001
	Mostly stood or walked around, n (%)	840 (50)	837 (64)	
	Mostly played active games, n (%)	645 (38)	122 (9)	
Main physical activity at lunchtime in last 5 school days	Mostly just sat down, n (%)	160 (10)	317 (24)	<0.001
	Mostly stood or walked around, n (%)	728 (43)	809 (61)	
	Mostly played active games, n (%)	792 (47)	190 (14)	
Number of days did active sports/dance/performance/games after school in last 5 school days	0, n (%)	177 (11)	148 (11)	<0.001
	1, n (%)	175 (10)	180 (14)	
	2, n (%)	319 (19)	305 (23)	
	3, n (%)	429 (26)	303 (23)	
	4, n (%)	255 (15)	204 (16)	
	5, n (%)	325 (19)	176 (13)	
Physically active every school day	No, n (%)	734 (44)	979 (74)	<0.001
	Yes, n (%)	946 (57)	337 (26)	
Average time (hours/day) watching TV/videos/DVDs	Median	1.29	1.00	<0.001
	IQR	0.71-2.29	0.57-2.00	
Average time (hours/day) playing video games or using computer (not homework)	Median	0.57	0.14	<0.001
	IQR	0.21-1.36	0.00-0.57	
Average screen time (hours/day)	Median	2.07	1.36	<0.001
	IQR	1.07-3.57	0.79-2.57	
Average screen time meeting	≤ 2 hours/day, n (%)	833 (50)	869 (66)	<0.001

recommendation	> 2 hours/day, n (%)	846 (50)	447 (34)	
School-day physical activity behaviours and screen-based media use	Not active every school day/ high screen-based media users, n (%)	337 (20)	299 (23)	<0.001
	Active every school day/ high screen-based media users, n (%)	363 (22)	84 (6)	
	Not active every school day/ low screen-based media users, n (%)	397 (24)	680 (52)	
	Active every school day/ low screen-based media users, n (%)	582 (35)	253 (19)	
95% CI, 95% confidence interval IQR, interquartile range = 25 th to 75 th percentile P*, Equality of distributions for males and females tested using Pearson Chi-square test or difference between medians for males and females tested using Wilcoxon rank-sum test, as appropriate Percentages may not equal 100 due to rounding				

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Table 3. Crude and adjusted regression estimates for PedsQL total score according to physical activity and sedentary behaviours of

Behaviour		Male						Crude Model
		Crude Model			Adjusted Model*			
		β (95% CI)	P	R ²	β (95% CI)	P	R ²	
Main physical activity at morning recess in last 5 school days			<0.001	0.023		<0.001	0.027	
	Mostly just sat down	Reference			Reference			Reference
	Mostly stood or walked around	2.85 (1.13, 4.57)	<0.01		3.00 (1.20, 4.79)	<0.01		1.57 (0.13, 3.02)
	Mostly played active games	5.28 (3.51, 7.06)	<0.001		5.31 (3.56, 7.07)	<0.001		4.20 (1.81, 6.59)
Main physical activity at lunchtime in last 5 school days			<0.001	0.045		<0.001	0.049	
	Mostly just sat down	Reference			Reference			Reference
	Mostly stood or walked around	5.50 (3.63, 7.36)	<0.001		5.58 (3.28, 7.88)	<0.001		2.72 (1.22, 4.22)
	Mostly played active games	8.10 (6.25, 9.95)	<0.001		8.11 (6.16, 10.1)	<0.001		6.11 (4.03, 8.18)
Number of days did active sports/dance/performace/games after school in last 5 school days			<0.001	0.048		<0.001	0.051	
	0	Reference			Reference			Reference
	1	-0.44 (-2.72, 1.85)	NS		-0.28 (-2.88, 2.31)	NS		2.07 (-0.42, 4.56)
	2	3.29 (1.28, 5.30)	<0.01		3.47 (0.38, 6.57)	<0.05		4.27 (2.02, 6.52)
	3	5.64 (3.73, 7.55)	<0.001		5.67 (3.89, 7.45)	<0.001		5.87 (3.62, 8.12)

	4	5.61 (3.51, 7.70)	<0.001		5.63 (3.95, 7.31)	<0.001		6.71 (4.29, 9.13)
	5	6.32 (4.32, 8.32)	<0.001		6.37 (3.24, 9.50)	<0.01		8.23 (5.72, 10.7)
Physically active every school day	No	Reference	<0.001	0.027	Reference	<0.001	0.030	Reference
	Yes	3.67 (2.61, 4.74)	<0.001		3.62 (2.80, 4.44)	<0.001		4.25 (2.82, 5.68)
Average time (hours/day) watching TV/videos/DVDs		-1.41 (-1.86, -0.96)	<0.001	0.022	-1.46 (-2.03, -0.90)	<0.001	0.028	-1.94 (-2.52, -1.3)
Average time (hours/day) playing video games or using computer (not homework)		-2.24 (-2.73, -1.75)	<0.001	0.045	-2.29 (-2.93, -1.65)	<0.001	0.052	-3.14 (-4.00, -2.29)
Average screen time (hours/day)		-1.26 (-1.54, -0.98)	<0.001	0.045	-1.30 (-1.70, -0.89)	<0.001	0.052	-1.82 (-2.24, -1.40)
Average screen time meeting recommendation	≤ 2 hours/day	Reference	<0.001	0.020	Reference	<0.001	0.026	Reference
	> 2 hours/day	-3.17 (-4.22, -2.11)	<0.001		-3.24 (-4.17, -2.30)	<0.001		-4.01 (-5.32, -2.69)
School-day physical activity behaviours and screen-based media use	Not active every school day/high screen-based media users	Reference	<0.001	0.046	Reference	<0.001	0.051	Reference
	Active every school day/high screen-based media users	3.41 (1.79, 5.03)	<0.001		3.30 (1.38, 5.22)	<0.01		3.66 (0.89, 6.42)
	Not active every school day/low screen-based media users	3.09 (1.51, 4.68)	<0.001		3.19 (1.49, 4.90)	<0.01		3.57 (2.02, 5.12)
	Active every school day/low screen-based media users	6.56 (5.09, 8.03)	<0.001		6.63 (5.23, 8.03)	<0.001		7.76 (5.84, 9.67)
95% CI, 95% confidence interval								
Adjusted Model*, Model adjusted for clustering effect of school and to control for weight status [5]								

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Table 4. Physical activity and sedentary behaviours of adolescents by age group

	Behaviour	< 15 years	≥ 15 years	P*
Main physical activity at morning recess in last 5 school days	Mostly just sat down, n (%)	207 (11)	345 (29)	<0.001
	Mostly stood or walked around, n (%)	1,052 (58)	625 (52)	
	Mostly played active games, n (%)	545 (30)	222 (19)	
Main physical activity at lunchtime in last 5 school days	Mostly just sat down, n (%)	196 (11)	281 (24)	<0.001
	Mostly stood or walked around, n (%)	967 (54)	570 (48)	
	Mostly played active games, n (%)	641 (36)	341 (29)	
Number of days did active sports/dance/performance/games after school in last 5 school days	0, n (%)	174 (10)	151 (13)	NS
	1, n (%)	212 (12)	143 (12)	
	2, n (%)	380 (21)	244 (20)	
	3, n (%)	436 (24)	296 (25)	
	4, n (%)	292 (16)	167 (14)	
	5, n (%)	310 (17)	191 (16)	
Physically active every school day	No, n (%)	987 (55)	726 (61)	<0.01
	Yes, n (%)	817 (45)	466 (39)	
Average time (hours/day) watching TV/videos/DVDs	Median	1.14	1.14	NS
	IQR	0.57-2.14	0.57-2.14	
Average time (hours/day) playing video games or using computer (not homework)	Median	0.36	0.29	<0.01
	IQR	0.14-1.00	0.07-0.93	
Average screen time (hours/day)	Median	1.71	1.71	NS
	IQR	0.86-3.14	0.93-3.00	
Average screen time meeting recommendation	≤ 2 hours/day, n (%)	1,014 (56)	688 (58)	NS
	> 2 hours/day, n (%)	789 (44)	504 (42)	
School-day physical activity behaviours and screen-based media use	Not active every school day/ high screen-based media users, n (%)	375 (21)	261 (22)	<0.01
	Active every school day/ high screen-based media users, n (%)	278 (15)	169 (14)	
	Not active every school day/ low screen-based media users, n (%)	612 (34)	465 (39)	
	Active every school day/ low screen-based media users, n (%)	538 (30)	297 (25)	

IQR, interquartile range = 25th to 75th percentile

P*, Equality of distributions for males and females tested using Pearson Chi-square test or difference between medians for males and females tested using Wilcoxon rank-sum test, as appropriate

Percentages may not equal 100 due to rounding

Table 5. PedsQL total score by physical activity and sedentary behaviours of adolescents in each age group

Behaviour	<15 years Mean ± SD	P*	≥ 15 years Mean ± SD	P*
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		(95% CI)		(95% CI)	
Main physical activity at morning recess in last 5 school days	Mostly just sat down	75.4±14.2 (73.4, 77.3)	<0.001	75.9±10.9 (74.8, 77.1)	<0.001
	Mostly stood or walked around	77.5±11.7 (76.8, 78.2)		78.6±11.0 (77.8, 79.5)	
	Mostly played active games	80.9±10.5 (80.0, 81.8)		80.6±9.6 (79.3, 81.9)	
Main physical activity at lunchtime in last 5 school days	Mostly just sat down	73.3±14.8 (71.2, 75.4)	<0.001	74.5±12.9 (73.0, 76.1)	<0.001
	Mostly stood or walked around	77.5±11.6 (76.8, 78.3)		78.4±10.1 (77.5, 79.2)	
	Mostly played active games	81.0±10.3 (80.2, 81.8)		81.0±9.1 (80.0, 82.0)	
Number of days did active sports/dance/performance/games after school in last 5 school days	0	75.2±14.4 (73.0, 77.3)	<0.001	72.3±11.8 (70.4, 74.2)	<0.001
	1	74.1±12.9 (72.3, 75.8)		75.2±12.2 (73.2, 77.2)	
	2	77.3±11.7 (76.1, 78.5)		77.9±10.2 (76.6, 79.2)	
	3	79.6±10.3 (78.6, 80.5)		79.9±9.9 (78.7, 81.0)	
	4	79.6±10.8 (78.4, 80.9)		80.6±9.5 (79.1, 82.0)	
	5	81.2±11.1 (80.0, 82.5)		81.0±9.8 (79.6, 82.4)	
Physically active every school day	No	76.5±12.3 (75.7, 77.2)	<0.001	76.6±11.4 (75.7, 77.4)	<0.001
	Yes	80.6±10.8 (79.8, 81.3)		80.8±9.3 (80.0, 81.7)	
Average screen time meeting recommendation	≤ 2 hours/day	79.7±11.0 (79.0, 80.3)	<0.001	79.5±10.2 (78.8, 80.3)	<0.001
	> 2 hours/day	76.6±12.5 (75.7, 77.5)		76.4±11.3 (75.4, 77.4)	
School-day physical activity behaviours and screen-based media use	Not active every school day/ high screen-based media users	74.5±13.5 (73.1, 75.8)	<0.001	74.7±12.6 (73.1, 76.2)	<0.001
	Active every school day/ high screen-based media users	78.6±11.0 (77.3, 79.9)		78.5±9.2 (77.1, 79.9)	
	Not active every school day/ low screen-based media users	77.7±11.3 (76.8, 78.6)		77.6±10.6 (76.6, 78.6)	
	Active every school day/ low screen-based media users	81.6±10.5 (80.7, 82.5)		82.1±9.1 (81.1, 83.2)	
95% CI, 95% confidence interval					
P*, Differences between means tested using <i>t</i> -test or one-way ANOVA, as appropriate					
Percentages may not equal 100 due to rounding					