Physical Activity and Sedentary Behaviors and Health-Related Quality of Life in Adolescents

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KEY WORDS

adolescents, physical activity, quality of life, screen time, Sydney Childhood Eye Study

ABBREVIATIONS

PedsQL—Pediatric Quality of Life Inventory
QoL—quality of life

Drs Gopinath and Mitchell were responsible for the conception and design of the study; Dr Mitchell performed data acquisition; Drs Gopinath, Baur, Burlutsky, and Mitchell conducted analysis and interpretation of data; and Drs Gopinath, Hardy, Baur, Burlutsky, and Mitchell revised the article for important intellectual content. All authors gave final approval of the version to be published.

www.pediatrics.org/cgi/doi/10.1542/peds.2011-3637

doi:10.1542/peds.2011-3637

Accepted for publication Mar 15, 2012

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PEDIATRICS (ISSN Numbers: Print, 0031-4005; Online, 1098-4275).

FINANCIAL DISCLOSURE: *The authors have indicated they have no financial relationships relevant to this article to disclose.*

FUNDING: The Sydney Childhood Eye Study was supported by the Australian National Health and Medical Research Council (grants 253732 and 512530); the Westmead Millennium Institute, University of Sydney; and the Vision Co-operative Research Centre, University of New South Wales, Sydney, Australia.

WHAT'S KNOWN ON THIS SUBJECT: There are limited cross-sectional data from observational studies of adolescents showing that regular participation in physical activity is associated with a higher quality of life status, whereas time spent in screen-based entertainment is associated with a poorer quality of life.

WHAT THIS STUDY ADDS: Adolescents who were physically active (particularly engaging in outdoor activity) over a 5-year period had higher quality of life than their less active peers. Conversely, high levels of screen-based entertainment over 5 years negatively affected quality of life status.

abstract

OBJECTIVE: Our goal was to assess cross-sectional and longitudinal associations between physical activity and sedentary behaviors (television viewing, computer and video-game usage, and reading) with health-related QoL.

METHODS: Of 2353 children surveyed (median age: 12.7 years), 1216 were resurveyed 5 years later, and 475 were newly recruited into the study (N = 1691). Children completed detailed activity questionnaires. Health-related QoL was assessed by using the Pediatric Quality of Life Inventory (PedsQL).

RESULTS: Cross-sectionally, after multivariable adjustment, adolescents in the highest versus lowest tertile of time spent in outdoor physical activity and television viewing had a higher (P_{trend} = .001) and lower (P_{trend} = .0003) total PedsQL score, respectively. Adolescents who remained in the highest tertiles compared with those in the lowest tertiles of total physical activity over the 5 years had significantly higher scores in the following areas: total (P_{trend} = .04), physical summary (P_{trend} = .0001), and social (P_{trend} = .02) domains. Conversely, those in the highest versus lowest tertile of screen-viewing time during follow-up reported significantly lower values in the following areas: total score (6.34-unit difference), physical summary (4.86-unit difference), psychosocial summary (7.09-unit difference), and emotional (8.33-unit difference) and school (9.78-unit difference) domains.

CONCLUSIONS: Regular physical activity over the long-term was associated with higher perceived health-related QoL among adolescents. Conversely, lower PedsQL scores were observed among those who spent the most time in screen-viewing activities. Improved understanding of these relationships could help in developing interventions to promote general well-being among adolescents. *Pediatrics* 2012;130:e167–e174

Physical activity and its associated health benefits in childhood and in later life are now well established, including reductions in both blood pressure and adiposity.[1–3] However, many children and adolescents in developed countries lead sedentary lifestyles.[4–6] A trend away from active leisure pursuits, and increased reliance on sedentary activities such as television viewing, is evident.[4] Sedentary lifestyles are known to be associated with childhood obesity, as well as with other problems such as violent behaviors.[4,7]

Health-related quality of life (QoL) refers to the subset of QoL directly related to an individual's health,[8] which as defined by the World Health Organization includes physical, mental, and social well-being.[9,10] There are cross-sectional data, albeit limited, demonstrating that children who regularly participate in physical activity compared with those who do not are more likely to report higher QoL status.[4,11,12] However, the relationship between physical and sedentary activities with perceived health status among adolescents is not sufficiently established.[13] A Spanish cross-sectional study of 1073 schoolchildren aged 11 to 13 years found that active adolescents generally have better QoL than their sedentary peers.[13] Recently, a cross-sectional study of 3040 Australian schoolchildren aged 11 to 18 years found that adolescents who were physically active and low screen-based media users had higher QoL scores.[14] By contrast, Boyle et al[15] did not observe significant differences in health-related QoL scores between children (11–15 years old) who achieved the recommended physical activity guidelines compared with those who did not.

We surveyed a large cohort of schoolchildren aged 12 years at baseline and 5 years later to: (1) establish the cross-sectional association between physical activity (outdoor and indoor) with health-related QoL scores in adolescents aged 17 to 18 years; (2) assess the cross-sectional relationship between sedentary behaviors (television viewing, computer and video-game usage, and reading) with health-related QoL; and (3) determine whether time spent in various physical and sedentary pursuits influences health-related QoL in the long-term, independent of confounding factors such as age, gender, ethnicity, parental education, and BMI.[9,12,16–18] This study is unique and expands on the current literature by focusing on: (1) adolescents (a relatively understudied age group); (2) the cross-sectional and temporal relationship between physical activity and sedentary behaviors with health-related QoL; and (3) a broad range of sedentary behaviors (ie, screen-viewing activities as well as time spent reading and doing homework) and physical activities (outdoor and indoor).

METHODS

Study Population

The Sydney Childhood Eye Study is a longitudinal population-based survey of eye conditions and other health outcomes in schoolchildren living within the Sydney metropolitan area of Australia. It was approved by the Human Research Ethics Committee, University of Sydney, the Department of Education and Training, and the Catholic Education Office, New South Wales, Australia.[19] We obtained informed written consent from at least 1 parent of each child and verbal assent from each child before the survey. Study methods have been described previously.[19] Briefly, students in a stratified random cluster sample of 21 high schools across Sydney (attending school year 7) were eligible to participate. Stratification was based on socioeconomic status data from the Australian Bureau of Statistics. The sample included a proportional mix of public, private, or religious high schools. Data for the 12-year-old cohort were collected during 2004–2005. Of the 3144 eligible 12-year-old children, 2367 were given parental permission to participate, and 2353 were surveyed (74.9%); their mean age was 12.7 years. At the 5-year follow-up study (during 2009–2011), 1216 of baseline participants (51.7%) were surveyed at age 17 to 18 years. Additional participants ($n = 475$) aged 17 to 18 years were recruited when we visited the same schools (a proportional mix of public, private, and religious high schools) as in the baseline survey. All eligible participants from the age group/school grade of interest were given a letter of invitation to participate, and we obtained informed written consent from the parents and verbal consent from the new recruits. Total number of participants surveyed at the 5-year follow-up aged 17 to 18 years was 1691. Information on time spent in physical and sedentary pursuits was collected at baseline and with follow-up surveys; however, health-related QoL was collected only at the 5-year survey.

Assessment of Physical Activity and Sedentary Behaviors

Adolescents self-reported the time usually spent in various physical and sedentary pursuits in an average week. The questions relating to sporting activity comprised a list of 9 sporting activities in which school-aged children participated: (1) dancing, gymnastics, calisthenics; (2) athletics; (3) swimming; (4) football, soccer, rugby league, Australian football; (5) netball, basketball; (6) tennis; (7) Kanga cricket (modified Australian version of cricket for children); (8) skating, riding a scooter, rollerblading; and (9) baseball, softball. The physical activities listed are those most commonly engaged in by this age group and represent those activities that are classified as having an energy expenditure of moderate-to-vigorous intensity, which is associated with health benefits. Students recorded the number

of hours per week they spent in each of these activities (ie, wrote in a response) and whether the activity was outdoors/indoors. In addition, adolescents were asked to report the type and duration of any other nonsporting activities they usually do outdoors. The time spent in each activity was summated, and the average hours per day were calculated separately for total (ie, all outdoor and indoor activities), outdoor (sporting and nonsporting), and indoor activities.

For sedentary activities, students were asked to think about an average week and to report the number of hours usually spent daily watching television, playing video games, using a computer (for fun and/or homework), reading for pleasure, and doing homework. The response categories were not at all, <1 hour per day, 1 to 2 hours per day, and ≥ 3 hours per day. Total screen time was the sum of time spent watching television, playing video games, and using a computer; sedentary behaviors comprised all screen time, reading, and doing homework.

Assessment of Health-Related QoL

The Pediatric Quality of Life Inventory (PedsQL) 4.0 was used to assess health-related QoL in preadolescents and adolescents and was only administered at the follow-up study. The PedsQL is a validated 23-item questionnaire for children aged 2 to 18 years[20] that takes students ~5 to 7 minutes to complete. The self-reported version of PedsQL was used in this study. Mean scores are calculated on the basis of a 5-point response scale for each item and transformed to a 0 to 100 scale; higher scores represent better QoL. The PedsQL yields 3 summary scores: a total scale score, a physical health summary score, and a psychosocial health summary score. There are 4 subscale scores: physical functioning, emotional functioning, social functioning, and school functioning. The total score comprises the average of all items in the questionnaire. The psychosocial summary is an average of the items in the emotional, social, and school functioning scales. The physical health summary score comprises the average of items in the physical functioning scale.[20]

Assessment of Covariates

Data were collected during a preorganized visit to each school. Anthropometric measures were obtained by a trained medical officer. Height was measured to the nearest 0.1 cm with shoes off by using a freestanding SECA height rod (model 220; SECA, Hamburg, Germany). Weight in kilograms was measured to the nearest 0.1 kg by using a standard portable weighing machine, after removing any heavy clothing. BMI was calculated as weight divided by height squared.

Parents were asked to complete a comprehensive 193-item questionnaire (at baseline and follow-up), from which sociodemographic information (including ethnicity) and highest level of parental education was collected.

Statistical Analyses

Statistical analyses were performed by using SAS version 9.1 (SAS Institute, Inc, Cary, NC) and included t tests, χ^2 tests, and linear regression. Linear regression models were constructed to examine possible associations between physical activity and sedentary behaviors (independent variables) with health-related QoL (dependent variable). Physical activity and sedentary behaviors were included in the analyses as continuous (each hour/day increase) or as categorical variables (tertiles). Total physical activity and total screen time were analyzed separately, as was each type of physical activity and sedentary behavior. Analysis of covariance was used to calculate differences in mean PedsQL scores adjusted for age, gender, ethnicity, BMI, and parental education. Trend analyses were performed by using ordinal variables containing median values for each tertile. Mixed models (PROC MIXED) was used to adjust for school clustering effect in regression analyses and in analysis of covariance. Of the 1691 students aged 17 to 18 years surveyed, 1094 had complete data on both activity and health-related QoL measures and were therefore included in cross-sectional analyses. We also assessed the temporal association between time spent in physical and sedentary activities with QoL. For these analyses, participants who remained in the first, second, and third tertiles of either physical or sedentary activity from baseline through to the 5-year follow-up examination (n = 775) were analyzed. For temporal analyses of QoL, tertile ranges were determined separately for the baseline and follow-up surveys. The low, moderate, and high sedentary behavior or physical activity groups represent participants who remained in the first, second, and third tertiles, respectively, during the 5 years at both baseline (age 12 years) and at follow-up (age 17–18 years).

RESULTS

Study characteristics of participants followed up (n = 1216) and those lost to follow-up (n = 1137) were compared. Participants versus nonparticipants were more likely to be East Asian (68.1% vs 31.9%) and South-East Asian (63.0% vs 37.0%; $P < .0001$), older (12.74 vs 12.67 years; $P = .0003$), have lower BMI (22.7 vs 22.8; $P = .01$), spend less time in total physical activity (2.4 vs 2.6 hours/day; $P = .001$), and playing video games (0.5 vs 0.6 hour/day; $P < .0001$) but spend more time doing homework (1.1 vs 1.0 hours/day; $P < .0001$) and reading (0.7 vs 0.6 hour/day; $P < .0001$).

Baseline characteristics of these participants are provided in Table 1. On average, adolescents spent 3.3 hours

TABLE 1 Baseline Characteristics of Study Participants Aged 17 to 18 Years

Characteristics	Study Participations (N = 1094)
Age, y	17.3 ± 0.6
Gender, male, *n* (%)	480 (43.9)
Ethnicity, *n* (%)	
Caucasian	590 (53.9)
East Asian	241 (22.0)
South-East Asian	80 (7.3)
Middle Eastern	87 (8.0)
Other	96 (8.8)
Parental education, *n* (%)[a]	460 (50.7)
BMI	22.7 ± 4.4
Reported time spent in sedentary behaviors, h/d	
Reading for pleasure	0.56 ± 0.7
Homework	1.50 ± 0.8
Screen time	3.27 ± 1.6
Television viewing	1.34 ± 0.8
Computer use	1.56 ± 0.9
Video-game usage	0.38 ± 0.6
Total physical activity, h/d	2.11 ± 1.5
Outdoor sporting activity	0.47 ± 0.6
Indoor sporting activity	0.17 ± 0.4

Data presented are mean ± SD or proportions.
[a] Mother and/or father has tertiary qualifications.

per day on recreational screen time and only 2.1 hours per day engaged in total physical activity. Table 2 shows that, after multivariable adjustment, adolescents in the highest tertile compared with those in the lowest tertile of total physical activity had a significantly higher total PedsQL score (3.15-unit difference), and higher scores in the physical summary (5.8-unit difference) and social (4.18-unit difference) domains. Similarly, when comparing highest with lowest tertile of outdoor physical activity, adolescents had a higher total score, and higher scores in the physical summary and social domains.

Table 3 shows that more time spent in total screen-viewing (television viewing, and video-game and computer usage) was associated with significantly lower adjusted mean total PedsQL scores: 3.53-, 3.51-, 3.41-, and 3.06-unit difference, respectively. Increasing time spent in total screen viewing and television viewing were both associated with lower scores in the physical summary, psychosocial summary, and emotional and school domains. In contrast, adolescents who spent the most time doing homework had significantly higher adjusted health-related QoL. Reading was not associated with PedsQL scores (data not shown).

Linear regression analyses revealed that each hour per day increase in total and outdoor physical activity was associated with a 1.5-unit and 2.6-unit increase in the physical summary score, respectively. Each hour per day spent in total screen-viewing activities, television viewing, and video-game usage was also inversely associated with adjusted mean scores in all domains, except the social domain (Table 4).

Participants who changed the time that they spent on each of the activities (eg, changed from the first tertile of television viewing at baseline to the third tertile by follow-up) were excluded from these analyses. Participants who remained in the highest compared with those in the lowest tertiles of total and outdoor physical activity over the 5 years had significantly higher total PedsQL score and physical summary and social domain scores (Table 5). Youth in the highest versus lowest tertile of screen-viewing time during the follow-up period reported significantly lower values in the following domains: total score, physical summary, psychosocial summary, and emotional and school (Table 6). Adolescents in the highest versus lowest tertile of time spent reading over the 5 years had significantly higher values in the school domain but lower values in the emotional and social dimensions.

TABLE 2 Cross-Sectional Association Between Time Spent in Physical Activity (Outdoor and Indoor) (Hours/Day) and Mean PedsQL Scores After Multivariable Adjustment in the Sydney Childhood Eye Study Among 17- to 18-Year-Olds (N = 1094)

Tertiles of Physical Activity	*n*	Adjusted Mean ± SE Score[a]					
		Total Score	Physical Summary	Psychosocial Summary	Emotional	Social	School
Total physical activity[b]							
Low ≤1.21	363	79.15 ± 0.9	86.64 ± 1.0	75.46 ± 1.0	73.26 ± 1.3	88.38 ± 1.0	65.38 ± 1.4
Moderate 1.21–2.50	360	80.78 ± 0.9	91.21 ± 1.0	75.60 ± 1.1	73.45 ± 1.3	89.92 ± 1.0	64.12 ± 1.5
High ≥2.57	359	82.30 ± 0.9	92.44 ± 1.0	77.25 ± 1.1	73.80 ± 1.4	92.56 ± 1.1	66.52 ± 1.5
P for trend		.004	<.0001	.16	.74	.001	.52
Outdoor sporting activity							
Low ≤0.07	272	79.65 ± 0.9	89.23 ± 1.0	75.00 ± 1.1	72.65 ± 1.4	89.05 ± 1.1	64.11 ± 1.6
Moderate 0.09–0.50	245	79.84 ± 1.0	89.61 ± 1.1	75.04 ± 1.2	72.40 ± 1.5	88.67 ± 1.2	64.99 ± 1.7
High ≥0.57	291	81.84 ± 1.0	92.72 ± 1.1	76.56 ± 1.2	73.97 ± 1.5	92.62 ± 1.2	64.03 ± 1.7
P for trend		.04	.001	.25	.42	.003	.83
Indoor sporting activity							
Low ≤0.00	565	80.83 ± 0.7	90.69 ± 0.9	76.07 ± 0.9	73.75 ± 1.2	90.84 ± 0.9	64.41 ± 1.3
Moderate–high ≥0.02	250	79.40 ± 1.0	90.33 ± 1.1	74.05 ± 1.2	71.06 ± 1.5	88.63 ± 1.2	63.56 ± 1.7
P		.16	.72	.10	.09	.06	.64

Adjusted means were calculated by using analysis of covariance. Tests for trend were based on ordinal variables containing median values for each tertile.
[a] Adjusted for age, gender, ethnicity, BMI, and parental education.
[b] Total physical activity time is the sum of both outdoor and indoor sporting activities, and outdoor leisure activities (eg, bushwalking) and outdoor activities (eg, riding a bike, walking, playing in backyard).

TABLE 3 Cross-Sectional Association Between Time Spent in Sedentary Behaviors (Hours/Day) and Mean PedsQL Scores After Multivariable Adjustment in the Sydney Childhood Eye Study Among 17- to 18-Year-Olds (*N* = 1094)

Tertiles of Sedentary Behavior	*n*	Adjusted Mean ± SE Score[a]					
		Total Score	Physical Summary	Psychosocial Summary	Emotional	Social	School
Total screen time							
1st tertile, ≤2.50	350	81.83 ± 0.9	91.19 ± 1.0	77.17 ± 1.1	75.27 ± 1.4)	89.86 ± 1.0	67.01 ± 1.5
2nd tertile, 2.57–3.86	387	81.79 ± 0.9	90.84 ± 1.0	77.32 ± 1.0	75.02 ± 1.3)	91.20 ± 1.0	66.51 ± 1.5
3rd tertile, ≥3.93	341	78.30 ± 0.9	87.62 ± 1.0	73.70 ± 1.1	70.16 ± 1.3)	89.37 ± 1.0	62.68 ± 1.5
P for trend		.001	.002	0.005	.002	.62	.02
Television viewing							
1st tertile, ≤1.07	346	82.40 ± 0.9	91.83 ± 1.0	77.77 ± 1.0	75.76 ± 1.3	89.69 ± 1.0	68.53 ± 1.5
2nd tertile, 1.14–1.29	290	81.25 ± 1.0	91.07 ± 1.1	76.36 ± 1.1	73.79 ± 1.5	91.53 ± 1.1	64.67 ± 1.7
3rd tertile, ≥1.50	436	78.89 ± 0.8	87.58 ± 0.9	74.54 ± 1.0	71.48 ± 1.2	89.84 ± 0.9	63.32 ± 1.4
P for trend		.0003	<.0001	0.01	0.01	.90	.004
Video-game usage							
1st tertile, ≤0.00	521	82.22 ± 0.8	90.75 ± 0.9	77.96 ± 1.0	75.58 ± 1.3	90.98 ± 0.9	68.04 ± 1.4
2nd tertile, 0.07–0.36	169	80.15 ± 1.2	89.79 ± 1.3	75.40 ± 1.4	73.31 ± 1.8	88.31 ± 1.3	65.31 ± 2.0
3rd tertile, ≥0.43	382	78.81 ± 0.9	88.66 ± 1.0	73.92 ± 1.1	70.83 ± 1.4	89.89 ± 1.0	62.14 ± 1.6
P for trend		.003	.08	.004	.01	.68	.002
Computer usage							
1st tertile, ≤1.14	317	81.91 ± 0.9	90.26 ± 1.0	77.74 ± 1.1	75.76 ± 1.4	91.37 ± 1.0	66.59 ± 1.5
2nd tertile, 1.29–2.36	406	81.26 ± 0.8	91.00 ± 1.0	76.49 ± 1.0	74.44 ± 1.2	90.17 ± 1.0	65.61 ± 1.4
3rd tertile, ≥2.57	353	78.85 ± 0.9	88.37 ± 1.0	74.19 ± 1.0	70.61 ± 1.3	89.13 ± 1.0	64.06 ± 1.5
P for trend		.004	.06	.01	.002	.07	.17
Homework							
1st tertile, ≤1.14	345	79.95 ± 0.9	88.85 ± 1.0	75.57 ± 1.1	76.08 ± 1.4	90.20 ± 1.0	60.16 ± 1.7
2nd tertile, 1.29–2.14	371	79.47 ± 0.9	89.21 ± 1.0	74.70 ± 1.0	71.69 ± 1.3	88.96 ± 1.0	64.41 ± 1.6
3rd tertile, ≥2.21	356	82.31 ± 0.9	91.32 ± 1.0	77.81 ± 1.0	73.05 ± 1.3	91.32 ± 1.0	70.94 ± 1.6
P for trend		.01	.03	.04	.14	.24	<.0001

Adjusted means were calculated by using analysis of covariance. Tests for trend were based on ordinal variables containing median values for each tertile.
[a] Adjusted for age, gender, ethnicity, BMI, and parental education.

TABLE 4 Linear, Cross-Sectional Associations Between Sedentary Behaviors With PedsQL Scores After Multivariable Adjustment in the Sydney Childhood Eye Study Among 17- to 18-Year-Olds (*N* = 1094)

PedsQL Domain	Multivariable-Adjusted Mean ± SE Difference in Score[a]									
	Screen Time		Television Viewing		Video-Game Usage		Computer Usage		Homework	
	β (SE)	*P*	β (SE)	*P*	β (SE)	*P*	β (SE)	*P*	β (SE)	*P*
Total score	−1.3 (0.3)	<.0001	−2.1 (0.6)	.0002	−2.7 (0.8)	.0004	−1.2 (0.5)	.02	1.5 (0.5)	.01
Physical summary	−1.1 (0.3)	.0002	−2.7 (0.6)	<.0001	−1.9 (0.8)	.02	−0.7 (0.6)	.23	1.5 (0.6)	.01
Psychosocial summary	−1.3 (0.3)	.0001	−1.8 (0.7)	.01	−3.1 (0.9)	.001	−1.4 (0.6)	.02	1.5 (0.6)	.02
Emotional	−1.7 (0.4)	<.0001	−2.4 (0.9)	.01	−3.2 (1.2)	.01	−2.3 (0.8)	.004	−1.3 (0.8)	.12
Social	−0.4 (0.3)	.25	0.2 (0.6)	.74	−1.3 (1.0)	.15	−0.8 (0.6)	.16	0.8 (0.6)	.20
School	−1.6 (0.5)	.001	−3.0 (1.0)	.002	−4.7 (1.3)	.0003	−0.8 (0.9)	.37	6.0 (0.9)	<.0001

Linear regression analysis was used to calculate standardized β coefficients (β) and *P* values.
[a] Adjusted for age, gender, ethnicity, BMI, and parental education.

DISCUSSION

The current study expands existing knowledge in this area by concurrently investigating the cross-sectional and longitudinal association between time spent in a wide range of physical and sedentary pursuits with health-related QoL in adolescents. A novel finding was that those adolescents who were physically active (particularly engaging in outdoor activity) over a 5-year period had higher health-related QoL than their less active peers. In contrast, adolescents who engaged in excessive screen viewing activities over the 5 years had significantly lower scores in multiple domains of the PedsQL.

The association between regular physical activity and better health-related QoL during adolescence concurs with previous population-based findings.[11,13,14,21] However, a key finding of the current study not previously reported was the differing associations between the type of physical activity and health-related QoL. An underlying reason for this difference could be that these adolescents spent little time in indoor physical activities (eg, basketball) compared with outdoor-based activities (eg, soccer)

TABLE 5 Temporal Associations Between Time Spent in Physical Activity (Hours/Day) With Mean PedsQL Scores After Multivariable Adjustment in the Sydney Childhood Eye Study Over 5 Years (n = 775)

Physical Activity at Both Baseline and Follow-up[b]	n	Adjusted Mean ± SE Score[a]					
		Total Score	Physical Summary	Psychosocial Summary	Emotional	Social	School
Total physical activity							
Low	140	79.57 ± 1.4	87.51 ± 1.5	75.54 ± 1.7	73.40 ± 2.2	87.31 ± 1.6	66.56 ± 2.5
Moderate	97	82.00 ± 1.6	92.88 ± 1.7	76.56 ± 2.0	74.65 ± 2.6	90.08 ± 1.9	65.64 ± 2.9
High	128	83.16 ± 1.6	94.72 ± 1.7	77.37 ± 1.9	74.00 ± 2.5	92.04 ± 1.8	67.21 ± 2.9
P for trend		.04	.0001	.39	.83	.02	.84
Outdoor sporting activity							
Low	76	78.68 ± 1.9	89.03 ± 1.9	73.50 ± 2.3	70.16 ± 3.1	88.21 ± 2.1	63.30 ± 3.4
Moderate	77	79.30 ± 2.1	89.11 ± 2.1	74.40 ± 2.5	69.61 ± 3.4	90.08 ± 2.3	65.16 ± 3.7
High	104	83.12 ± 1.9	95.11 ± 1.9	77.13 ± 2.3	73.47 ± 3.1	93.54 ± 2.1	65.64 ± 3.3
P for trend		.03	.003	.14	.30	.02	.53
Indoor sporting activity							
Low	56	80.75 ± 2.5	94.35 ± 2.8	73.97 ± 3.1	69.46 ± 4.2	89.98 ± 3.1	63.32 ± 4.5
Moderate–high	94	79.66 ± 2.4	93.35 ± 2.7	72.91 ± 1.2	68.00 ± 4.0	89.43 ± 3.0	63.00 ± 4.3
P		.63	.69	.70	.69	.84	.94

Adjusted means were calculated by using analysis of covariance. Tests for trend were based on ordinal variables containing median values for each tertile.

[a] Adjusted for age, gender, ethnicity, BMI, and parental education.

[b] The low, moderate, and high activity groups represent participants who remained in the first, second, and third tertiles, respectively, over the 5 years at both baseline (age 12 years) and at follow-up examinations (age 17–18 years).

TABLE 6 Temporal Association Between Time Spent in Sedentary Behaviors (Hours/Day) and Mean PedsQL Scores After Multivariable Adjustment in the Sydney Childhood Eye Study Over 5 Years (n = 775)

Sedentary Behavior at Both Baseline and Follow-up[b]	n	Adjusted Mean ± SE Score[a]					
		Total Score	Physical Summary	Psychosocial Summary	Emotional	Social	School
Total screen time							
Low	127	82.21 ± 1.5	90.58 ± 1.6	78.06 ± 1.1	75.31 ± 2.4	90.46 ± 1.8	69.58 ± 2.8
Moderate	111	81.88 ± 1.6	89.49 ± 1.7	78.10 ± 1.9	76.92 ± 2.5	90.69 ± 1.9	66.84 ± 2.9
High	128	75.87 ± 1.6	85.72 ± 1.7	70.97 ± 1.9	66.98 ± 2.5	87.30 ± 1.9	59.80 ± 2.9
P for trend		.001	.02	.002	.01	.17	.003
Television viewing							
Low	118	81.79 ± 1.6	91.63 ± 1.8	76.97 ± 1.8	76.17 ± 2.5	89.46 ± 1.8	66.07 ± 2.7
Moderate	95	79.98 ± 1.6	89.70 ± 1.9	75.11 ± 1.9	73.78 ± 2.5	90.94 ± 1.9	60.97 ± 2.8
High	104	77.46 ± 1.7	85.94 ± 1.9	73.22 ± 2.0	71.31 ± 2.7	89.05 ± 2.0	59.74 ± 2.9
P for trend		.03	.01	.10	.10	.91	.05
Reading books for pleasure							
Low	122	82.91 ± 1.6	92.52 ± 1.8	78.09 ± 2.0	79.01 ± 2.5	93.13 ± 1.8	61.75 ± 2.8
Moderate	138	83.05 ± 1.5	92.14 ± 1.6	78.54 ± 1.8	76.38 ± 2.3	92.52 ± 1.6	67.51 ± 2.6
High	119	80.93 ± 1.5	89.44 ± 1.6	76.65 ± 1.8	72.31 ± 2.4	88.69 ± 1.7	70.33 ± 2.9
P for trend		.27	.12	.50	.02	.03	.01

Adjusted means were calculated by using analysis of covariance. Tests for trend were based on ordinal variables containing median values for each tertile.

[a] Adjusted for age, gender, ethnicity, BMI, and parental education.

[b] The low, moderate, and high sedentary behavior groups represent participants who remained in the first, second, and third tertiles, respectively, during the 5 years at both baseline (age 12 years) and at follow-up examinations (age 17–18 years).

and, hence, the association between indoor physical activity and health-related QoL could have been underestimated. Moreover, our findings may not be necessarily applicable to other regions (eg, North America and Canada) where winter is comparatively more severe than the temperate Sydney climate, which in turn could translate into more participation in indoor rather than outdoor physical activity in these regions.[22]

The positive link between a physically active lifestyle and health-related QoL in the long-term was primarily driven by better functioning in the physical summary and social dimensions. This is not altogether surprising as physically active adolescents are probably less likely to report limitations in basic activities of daily living such as walking several blocks and lifting. The better social functioning among active adolescents could be due to the link between sporting activity participation and the development of social reinforcement and having increased social desirability.[23] Moreover, adolescents who rarely exercised were more likely to self-report feelings of loneliness and

shyness, partly explaining the poorer scores in the social domain among physically inactive youths.[24] The lack of an independent association between physical activity and the psychosocial health summary and emotional domains is in agreement with previous adult studies.[25–27]

Excessive recreational screen time, particularly television viewing, over the 5 years was associated with lower scores in multiple PedsQL domains among adolescents and confirms data from a cross-sectional study.[14] Previous studies have shown that frequent screen time is related to health outcomes, which are linked to health-related QoL such as reduced psychological well-being,[27] poorer physical health,[28] lower self-esteem,[21,27] reduced life satisfaction,[14,28] and poorer cognitive performance.[29] The passive nature of many screen-viewing activities probably underlies its association with these negative health indicators. For instance, time spent watching television is time not spent engaging in social interactions or testing the limits of one's cognitive and physical capabilities.[14,28]

To the best of our knowledge, the independent, temporal association between reading and measures of health-related QoL has not previously been reported in adolescents or adults. It is intuitive that increased time spent reading might be a marker of better school performance and academic achievement, which is reflected in the higher values in the school domain. However, more time spent in reading could also mean fewer opportunities for social development and building peer networks, all of which could lead to feelings of loneliness and shyness and, hence, negatively affect the social and emotional PedsQL domains.

Our results are consistent with studies showing that screen-based entertainment could be an independent health risk.[22,27–30] These findings emphasize to pediatric clinicians and researchers the importance of evaluating lifestyle factors, such as activity behaviors, when inquiring about QoL in routine assessments in clinical practice and in clinical trials involving adolescents. The current data could also contribute to the evidence base for public health interventions focused on promoting physical activity and reducing screen-based entertainment among adolescents. Activity promotion efforts are warranted in the school environment (eg, making better facilities available in school playgrounds, policies regarding physical education), as well as in noninstitutionalized environments such as the home.[21] In addition, parents may need to monitor and limit adolescent screen-time, although little is known about how best to achieve this and what effect such efforts would have on screen-viewing time.[14,31]

There are several strengths of this study, including its longitudinal design, random cluster sample of a relatively large number of schoolchildren, and use of a validated pediatric health-related QoL instrument. Limitations of our study also deserve discussion. First, we used self-reported rather than an objective measurement of time spent in physical and sedentary activities. However, the use of self-reported questionnaires in large population surveys is common practice[32] given the large costs, logistics, and expertise required to use criterion measures such as accelerometers. Furthermore, our findings need to be interpreted with caution because the measures of physical activity and sedentary behaviors were not validated, and we were not able to collect duplicate measures of height and weight. Second, although ours is a cohort study, only demographic, anthropometric, and activity measures (but not PedsQL data) were collected at the baseline survey. We therefore cannot determine the association between time spent in physical and sedentary activities with health-related QoL at age 12 years, nor can we ascertain changes in health-related QoL over the 5 years. Third, although we adjusted for a number of important confounders, we cannot discount the possibility that other unmeasured factors such as parental well-being, dietary parameters, and other societal factors could have influenced health-related QoL in this cohort. Finally, we cannot rule out the possibility of selection bias, as ~50% of baseline participants were lost to follow-up and significant differences in study characteristics between participants and nonparticipants were observed, which could have influenced our results.

CONCLUSIONS

We found that frequent participation in outdoor physical activity in the long-term was associated with better health-related QoL in adolescents. In contrast, high levels of screen entertainment use over 5 years were associated with poorer health-related QoL. These findings reiterate the need for public health policy and interventions that promote less time in recreational screen viewing and more time in physical activity, which could have a beneficial influence not only on weight and fitness but also on general well-being during adolescence and beyond.

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Pediatrics 2012;130;e167; originally published online June 11, 2012;
DOI: 10.1542/peds.2011-3637

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