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Original article

Interrelationships of adolescent physical activity, screen-based sedentary behaviour, and social and psychological health

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Abstract

Objectives: To examine how adolescent physical activity (PA) and screen-based media sedentary behaviours (SBM) relate to psychological and social health and identify cross-national differences in these relationships.

Methods: Associations were examined in five regions using two Health Behaviour in School-Aged Children (HBSC) countries from each.

Results: Self-reported psychological and social health indices such as self-image, perceived health status, and Life Satisfaction were positively related to PA in all five regions but, with a few exceptions, negatively related to SBM. Negative health indices such as health complaints and tobacco use were negatively related to PA but, with exceptions, positively related to SBM. Significant regional differences were present.

Conclusions: Regional differences in correlates of PA and SBM suggest cultural differences in potential effects of PA and SBM and the need to tailor school and public health efforts to the different meanings of PA and SBM for positive and negative health consequences.

Keywords: Physical activity – Sedentary behaviour – Life satisfaction – Social relationships – Health complaints – Substance use.

Introduction

Physical activity (PA) is any physical movement or muscular exertion which increases energy expenditure; moderate to vigorous physical activity (MVPA) raises energy expenditure to at least three times one's basal metabolic rate. The increase in energy expenditure and resulting challenge to pulmonary-cardiovascular systems has a number of beneficial effects on physical health, particularly improved cardiovascular functioning[1]. Sedentary behaviour on the other hand is any behaviour which maintains a level of energy expenditure close to that when one is resting; sedentary behaviours that involve screen-based media use (SBM) usually refer to leisure-time activities such as watching television, playing video or computer games, or using a computer. The reduced energy expenditure during periods of SBM may contribute a positive energy balance (i.e., less energy expenditure relative to energy intake) and has been associated with obesity and obesity-related health problems[2].

Although there has been extensive research linking MVPA to markers of physical health such as decreased adiposity, improvement in Metabolic Syndrome (abdominal obesity, elevated blood pressure, elevated fasting glucose, and reduced HDL), decreased triglyceride level, increased HDL, bone

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density, muscular strength and endurance, and aerobic fitness, and improved mental health, studies relating PA to social and psychological health indicators have been less prevalent[1,3].

Two potential mechanisms have been suggested for positive relationships between PA and psychological and social health. One set of hypotheses credits the physiological effect of PA on monoamines in the brain affecting neurotransmission or on the production of endorphins and their pain reduction and euphoric effects[4]. Alternatively, PA has been associated with positive self-concept and the reduction of anxiety and depression in adolescents; these positive psychological effects could generalize to improved management of stress and impact social interactions as well[1,4–8]. However, the relationship of PA with social relationships (quality of family and peer relationships), health complaints, and negative health behaviours (aggression, tobacco use, and alcohol use and abuse) have either received little attention or focused on particular populations (athletes, local samples)[7,9–14].

In addition to the potential effect of SBM on adiposity[2], SBM has been associated with muscular-skeletal pain and behavioural problems such as aggression and substance use[15,16]. Because SBM is an indicator of inactivity, it might be assumed that SBM would have the opposite effects on psychological and social health as PA; however, research on the relationship between SBM and social and behavioural health indicators is characterized by noticeable gaps or inconsistent findings[17–19]. Differences in findings may represent cultural differences in the samples studied. In order to strengthen the evidence base in this area, additional research identifying cross-cultural similarities and differences in potential influences of PA and SBM on various indicators of health is warranted.

The current paper examines independent associations of PA and SBM with positive and negative health indicators in large nationally-representative samples from North America and Europe. It was predicted that PA would have positive associations with positive health indicators and negative relations with negative health indicators. The opposite pattern was predicted for SBM.

Methods

Identical self-report questions were used to survey students ages 11, 13 and 15 from countries participating in the Health Behaviour in School-Aged Children (HBSC) study during the 2005–2006 school year[20]. Self-completion questionnaires were administered in school classroom in each participating country and region, with requirements in terms of sampling, questionnaire items and survey administration being set out in a standardised research protocol. All of the questions used in the HBSC survey must have evidence of reliability and validity when used with children in multiple countries before they are considered for inclusion[20]. In the majority of countries, national representative samples were drawn and samples were stratified to ensure representation of relevant subgroups. Cluster sampling was used, the primary sampling unit being school class (or school where a sampling frame of classes was not available). A total of 204,534 young people aged 11, 13 and 15 years from 41 countries participated in the last survey. Each age group was represented by approximately 1 500 students, assuming a 95 % confidence interval of +/- 3 per cent around a proportion of 50 per cent and thus, allowing for a clustered nature of the samples. Participation in the survey was voluntary and each country conformed to the ethical and legal requirements of their country. Full details of the study's development and methods employed can be found in this supplement and elsewhere[20,21].

Ten HBSC countries, two from each region, were randomly selected to represent North America (NA; U.S., Canada), Western Europe (WE; Switzerland, Netherlands), Eastern Europe (EE; Czech Republic, Poland), Northern Europe (NE; Finland, Norway), and Southern Europe (SE: Italy, Spain).

Physical Activity: After reading a definition of moderate-to-vigorous PA and examples, students indicated the number of days (from zero to 7) they engaged in at least 60 minutes of PA over the past seven days. This measure has been shown to have good reliability and validity[22] and HBSC national averages are consistent with studies using other measures of PA[23–26].

Screen-based Media Use: SBM was estimated using 2 two-part questions asking how many hours (none, ½, 1 to 7 or more) per weekday and weekend day was spent: 1) using a computer during free time (excluding time spent doing homework), and 2) watching television (including videos). Using the values indicated, mean hours per day of both screen-based activities were calculated and summed to create a SBM score[27].

Physical Self-Image: Perception of one's body size indicated satisfaction with self-image ('just right' scored as 3) versus dissatisfaction ('a bit too thin' or 'a bit too fat' scored as 2, and 'much too thin' or 'much too fat' scored as 1)[28].

Perceived Health Status: Perceived health status was self-rated (4-point scale: fair, poor, good, and excellent)[29].

Life Satisfaction: Participants indicated where they stood on a 10-point ladder with zero being the 'worst possible life' and 10 being the 'best possible life'[30].

Quality of Family Relationships: Participants indicated how easy (4-point scale: very difficult, difficult, easy, and very easy) it was to talk to specific others about things that were bothering them. A mean score was derived from responses about six family members (excluding family members they

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don't see or have): father, step-father, mother, step-mother, older brother and older sister (Cronbach's alpha = .81)[31].

Quality of Peer Relationships: Three items asked whether it was easy to talk with a best friend, friends of the same sex, and friends of the opposite sex (4-point scale: very difficult, difficult, easy, and very easy). Two items asked the number of close male and female friends: none, one, two, or three or more. Two items asked how many days/week they usually spent time with friends immediately after school (zero to five+) and how many evenings/week they usually spent time with friends (zero to seven)[31]. A weighted mean (each response divided by the maximum possible score for that item) of the seven items was the index for quality of peer relationships (Cronbach's alpha = .66).

Health Complaints: Participants indicated how frequently (5-point scale: rarely or never, about every month, about every week, more than once a week, and about every day) they had each of eight symptoms (headache, stomach-ache, backache, feeling low, irritability or bad temper, feeling nervous, difficulties getting to sleep, feeling dizzy)[32]. A mean of the responses represented subjective health complaints (Cronbach's alpha = .80).

Physical Aggression: A mean of two items contributed to an index of physically aggressive behaviour: frequency of bullying other students in the past two months (5-point scale: I haven't bullied another student(s) at school in the past couple of months, it has only happened once or twice, 2 or 3 times a month, about once a week, and several times a week); and number of times in a physical fight in the past 12 months (5-point scale: I have not been in a physical fight, 1 time, 2 times, 3 times, and 4 times or more)[33,34]. A weighted mean of the two items was used for the index of aggression.

Tobacco Use: A single item asking "How often do you smoke tobacco at present?" (4-point scale: I do not smoke, less than once a week, at least once a week but not every day, and every day) indicated cigarette smoking[35].

Alcohol Use and Getting Drunk: Alcohol use indicated the highest frequency of use (converted to days/week: never (0), rarely (.1), every month (.25), every week (1), and every day (7)) of beer, wine, or liquor/spirits. Students also indicated if they had ever had so much alcohol that they were really drunk (5-point scale: never, once, 2–3 times, 4–10 times, and more than 10 times)[36].

Analysis plan

Item distributions were evaluated. Skewed distributions for tobacco use and the two alcohol questions were adjusted using log transformations; however, to simplify the interpretation, the means shown in Table 1 are prior to transformation.

PA and SBM were initially regressed on age, gender, and the other activity variable (PA or SBM) to determine the relation of each of the activity variables to age and gender. Regression models including age, gender, PA and SBM indicated how PA and SBM independently related to each of the positive and negative health indices within each region. Because a disproportionate number of existing studies have been conducted with samples from North America and previous work examined these relationships in larger national samples from the U.S. and Canada[37], North America was used as the reference region to determine if cultural differences might account for differences in findings across study samples. To examine potential regional effects, regression models paired North America with each European region; region by predictor variable interaction terms indicated whether associations were significantly different across regions. To control for cluster effects of the sampling design, SAS Version 9.1 Survey procedures were used for all analyses. Measures were standardized, pooling data from all countries, prior to regression analyses. Missing items within a multi-item scale were addressed by using a weighted mean of all remaining items. Listwise deletion was used when an element of the regression model was missing. Missing responses were distributed equally across age groups and averaged less than 3 % with the exception of alcohol questions in Southern Europe (29 %). Because analyses were repeated in five regions, the significance level was set at $p < .01$.

Results

Self-reported physical activity (PA) varied across regions; adolescents in North America (NA) reported the highest rate and in Southern Europe (SE) reported the lowest. Screen-based sedentary behaviour (SBM) was highest in Eastern Europe (EE) and lowest in SE (Tab. 1). In all regions, PA decreased significantly with age and boys reported significantly more PA than girls (Tab. 2); similar to PA, SBM was higher in boys than girls (Tab. 3). However, SBM increased with age in Western Europe (WE), Northern Europe (NE), and SE, decreased with age in NA, and was unrelated to age in EE (Tab. 3). PA and SBM were unrelated in three regions but were negatively related in NA and NE (Tab. 2).

Across all regions, PA was positively related to all five indices of positive psychological and social health (Tab. 2). The associations of PA with perceived health status and peer relationships were the strongest across regions with average standardized regression coefficients of .18.

In all five regions, PA was negatively related to health complaints and in four of the five regions negatively related to tobacco use (Tab. 2). However, PA was positively related to

Table 1. Regional Means (Standard Deviations) of Physical Activity, Screen-based Media Use, and Positive and Negative Health Indicators.

Variable	North America	Western Europe	Eastern Europe	Northern Europe	Southern Europe
Sample Size	9444	8558	10126	8770	12226
Age (years)	13.8 (1.5)	13.5 (1.6)	13.8 (1.7)	13.6 (1.7)	13.6 (1.7)
Physical Activity (days/week ≥ 1 hr)	4.5 (2.1)	4.1 (2.0)	4.1 (2.1)	4.3 (2.0)	3.9 (2.1)
Screen-based Media Use (hours/day)	4.1 (2.9)	3.7 (2.7)	4.3 (2.8)	3.6 (2.3)	3.5 (2.3)
Positive Health Indices					
Self-Image (1 to 3)	2.5 (.60)	2.5 (.59)	2.4 (.66)	2.5 (.62)	2.5 (.60)
Perceived Health Status (1 to 4)	3.1 (0.7)	3.3 (0.7)	3.2 (0.7)	3.2 (0.7)	3.3 (0.6)
Life Satisfaction (0 to 10)	7.4 (1.8)	7.8 (1.7)	7.3 (1.9)	7.9 (1.7)	7.9 (1.8)
Quality of Family Relationships (1 to 4)	2.8 (0.8)	3.0 (0.7)	3.0 (0.7)	2.9 (0.7)	3.0 (0.7)
Quality of Peer Relationships (0 to 1)	.66 (.18)	.61 (.18)	.64 (.18)	.65 (.18)	.68 (.17)
Negative Health Indices					
Health Complaints (0 to 4)	1.1 (0.8)	.86 (.74)	1.1 (0.8)	.99 (.73)	.97 (.82)
Physical Aggression (0 to 1)	.14 (.20)	.13 (.19)	.15 (.02)	.10 (.17)	.13 (.19)
Tobacco Use (0 to 3)	.17 (.59)	.22 (.71)	.30 (.82)	.23 (.72)	.24 (.74)
Alcohol Use (days/week)	.18 (.83)	.14 (.65)	.22 (.94)	.09 (.40)	.35 (1.30)
Drunk (0 to 3)	.51 (1.04)	.36 (.85)	.61 (1.06)	.48 (1.07)	.50 (.99)

Table 2. Regional Regression Coefficients for Demographics and Positive and Negative Health Indicators with Physical Activity.

Variable	North America	Western Europe	Eastern Europe	Northern Europe	Southern Europe
Age	-.13***	-.08*** A	-.06*** A	-.21*** A	-.12*** A
Gender	.20***	.10*** A	.17*** A	.12*** A	.16*** A
Screen-based Media Use	-.15***	-.00 A	-.03 A	-.14***	.01 A
Positive Health Indices					
Self-Image	.11***	.06***	.07***	.08***	.09***
Health Status	.26***	.11*** A	.12*** A	.25***	.17*** A
Life Satisfaction	.15***	.10***	.11***	.16***	.16***
Family Relationships	.10***	.11***	.06*** C	.11***	.09***
Peer Relationships	.22***	.15*** A	.19***	.19***	.17***
Negative Health Indices					
Health Complaints	-.07***	-.08***	-.03*	-.05***	-.12*** B
Physical Aggression	.06***	.02	.05***	.01 C	.01
Tobacco Use	-.02	-.04** C	-.03*	-.04* C	-.03** C
Alcohol Use	.03**	.06***	.03*	.00	.02
Drunk	.04**	-.01	.03	-.00 B	.01

Note: Standardized regression coefficients with age, gender, PA and SBM in the model.
*p <.01; **p <.001; ***p <.0001.
A A significant (p <.0001) difference in the regional coefficient compared to the North American coefficient.
B A significant (p <.001) difference in the regional coefficient compared to the North American coefficient.
C A significant (p <.01) difference in the regional coefficient compared to the North American coefficient.

alcohol use in three regions, positively related to aggression in two regions, and related to getting drunk in one region. The one region with a consistent pattern of positive relations between PA and aggression, alcohol use, and getting drunk was NA. However, for all regions the coefficients for physical aggression, tobacco use, alcohol use and getting drunk were quite small.

To evaluate regional differences, each of the four European regions was compared to NA. There were no significant regional differences in the associations of PA with self-image, Life Satisfaction, or alcohol, where the associations were either positive or non-significant. (Tab. 2). For the remaining positive and negative health indices, regions primarily differed in the strength of the relationships but not in direction. Where significant differences with NA existed, the strength of associations with PA was significantly weaker in EE but the

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Table 3. Regional Regression Coefficients for Positive and Negative Health Indicators with Screen-Based Media Use.

Variable	North America	Western Europe	Eastern Europe	Northern Europe	Southern Europe
Age	-.09***	.13*** A	-.01 A	.04** A	.07*** A
Gender	.25***	.25***	.33*** B	.26***	.18*** B
Positive Health Indices					
Self-Image	-.05***	-.07***	-.05***	-.12***	-.08***
Health Status	-.07***	-.10***	.02 A	-.09***	-.02 B
Life Satisfaction	-.09***	-.03* A	-.03 A	-.09***	-.06***
Family Relationships	-.03*	.03* C	.02 C	-.04*	-.04***
Peer Relationships	.05***	.12*** A	.13*** A	.07***	.10*** A
Negative Health Indices					
Health Complaints	.11***	-.02 A	.04*** A	.11***	.13***
Physical Aggression	.12***	.14***	.14*** B	.15***	.17*** B
Tobacco Use	.03*	.04**	.06***	.03	.03
Alcohol Use	.07***	.12***	.10***	.08***	.09***
Drunk	.04***	.06***	.10*** A	.04*	.03*

Note: Standardized regression coefficients with age, gender, PA and SBM in the model.
*p <.01; **p <.001; ***p <.0001.
A A significant (p <.0001) difference in the regional coefficient compared to the North American coefficient.
B A significant (p <.001) difference in the regional coefficient compared to the North American coefficient.
C A significant (p <.01) difference in the regional coefficient compared to the North American coefficient.

direction of effects was mixed in the other three regions.

In all five regions, higher levels of SBM were associated with poorer self-image (Tab. 3). More frequent SBM was associated with poorer Life Satisfaction in four regions and poorer perceived health status and family relationships in three regions. However, SBM was positively related to family relationships in WE and positively related to quality of peer relationships in all regions.

The pattern for associations between SBM and negative health indices was very different (Tab. 3). Where significant relationships were found, they were uniformly in a positive direction. In all five regions, SBM was positively related to aggression, alcohol use, and getting drunk. The strongest association was with physical aggression where the average coefficient across regions was 0.14.

There were more regional differences for associations with SBM than there were for PA (Tab. 3). EE differed from NA in seven of ten health index comparisons. NE and NA were comparable in the magnitude and direction of coefficients for all health indices.

Discussion

In addition to known physical benefits, the present study demonstrates that PA appears to be positively related to psychosocial health and other health behaviours for school-aged children. The only exceptions appear to be an association with aggression and alcohol use. In contrast, it appears that across regions SBM is associated with a range of health risks and lower Life Satisfaction beyond those previously studied. These findings are troublesome because children in none of the regions studied averaged sufficient PA to meet the minimum guidelines of at least 60 min of PA five days a week[1] and in all regions the average child spent significantly more time per day engaged in SBM than the recommendations for no more than two hours per day of SBM[17] (see Tab. 1).

One theory for potential negative health effects of SBM is that time spent in sedentary activities displaces time available for PA[38]. However, SBM was not significantly related to PA in three regions. Furthermore, in all regions studied, boys were higher in both PA and SBM than girls. And while PA consistently decreased across age in all five regions, SBM increased across age in only three of the five regions. These results suggest that adolescents are not replacing PA with SBM. Finally, even with PA in the equation SBM had significant negative associations with health indices. Although PA generally had a positive association with positive health indices and negative associations with negative health indices, the pattern of associations for SBM was not a mirror image and regression coefficients were still significant when both PA and SBM were in the models. Overall, a strong argument can be made that PA and SBM are independent behaviours, each with significant health correlates.

PA may have broad positive relationships to mental as well as physical health as evident in the positive associations with

positive health indices. The positive effects of PA on psychological and social health may be due to physiological effects of PA or to the positive effects of PA on mental health indicators such as self-esteem and self-concept[4]. The uniformly positive relations between PA and self-image would support these hypotheses; however, PA appears to have even stronger relations with perceived Life Satisfaction and quality of peer interactions.

Although the size of many of these associations was modest, the consistent pattern across regions and the fact that PA levels were below recommended guidelines while SBM levels were substantially above recommended guidelines suggest that these behaviours could have significant public health implications. In addition to better physical health and fewer health complaints, PA was associated with better mental and social health (self-image, Life Satisfaction, family, and peer relationships) and lower prevalence of a major health risk behaviour (cigarette use). So far, physical activity interventions for children and adolescents have to a large extent focused on the public health effect of reducing the emerging paediatric overweight epidemic and maximizing physical health. The present findings provide additional justification for public health strategies to increase physical activity for the general population and for more structured intervention efforts focusing on children at risk for developing mental health problems and risky behaviours.

Although there were regional differences in these associations, in most cases they were differences in the magnitude of the associations rather than the direction.

In contrast, SBM had a pattern of negative relationships with self-image and Life Satisfaction and positive associations with physical aggression, getting drunk, and quality of peer relationships. In most regions, SBM was negatively related to perceived health status and quality of family relationships and positively related to health complaints, smoking and alcohol use. Thus, with the exception of quality of peer relationships, SBM would appear to be associated with poorer psychological and social health.

Relations between psychological and social health for SBM were not a mirror image of those for PA. This suggests that the mechanism for the effects of SBM on these health indices is not simply due to inactivity. In all regions, SBM was positively related to quality of peer interactions but generally had negative effects on health. One explanation for the negative effects of SBM on these health indicators is the content of television programming and computer games. Further exploration of regional differences in television programming and the correlates of SBM may shed light on this explanation.

Alternatively, it may be that children with poor physical and mental health choose to spend more time on SBM. Still, efforts to replace some screen-based activity with participation in PA are likely to have a positive effect for children reporting poor physical and mental health. Substantial regional differences suggest that engaging in SBM may have different meaning in different cultures, and be influenced by behavioural traditions. Therefore, efforts to modify SBM need to take these cultural differences into account.

Physical aggression is one exception to the contrasting relationships of PA and SBM with health indices. PA was not significantly related to physical aggression in two regions and was weakly but positively associated in the other three. It may be that cultural differences with regard to organized PA (e. g., youth sport teams) establish different expectations regarding personal behaviour[39]. Cross-country differences in the prevalence of contact sports may also influence this relationship[40]. As in previous research[15,16], SBM was consistently related to aggression across regions. Violent content of television, videos, and computer games as well as aggressive conflicts displayed during televised sports needs to be considered if the association of PA and SBM with youth aggression is to be addressed.

The other exception to the pattern is in quality of peer relationships; both PA and SBM were positively associated with peer relationships. The positive association between SBM and quality of social relationships is particularly interesting. TV viewing and computer use are an active part of the peer culture and may reflect overall peer socialization[41]. Interestingly, in some cultures these SBM activities were associated with a poorer quality of family communication.

A limitation of this study is that the data are cross-sectional and do not permit inferences about causality. Still, these associations are a first step in generating hypothesis for further research. In addition, all of the indices are based on self-report. Finally, the sample does not include countries outside of Europe and North America.

These limitations need to be balanced against the considerable assets of this study. The dataset includes large, nationally-representative samples representing different countries and cultures. The consistent patterns of results across countries and regions are compelling.

PA and SBM do not appear to be opposite ends of a single dimension. The study adds to previous research by demonstrating consistent cross-regional positive associations between PA and psychological and social health, as well as negative associations between SBM and these health indicators. This provides additional justification for intervention efforts. It is likely that psychological and social health effects could serve as effective motivators because they provide immediate benefits compared to the long-term risk of cardiovascular disease. However, regional differences in the correlates of

PA and SBM suggest cultural differences in effects and the need to tailor school and public health efforts to the different meanings of PA and SBM for positive and negative health consequences. More research is needed, particularly for SBM which has received less attention than PA and for which only a limited number of countries have developed official health recommendations.

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