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Original research

The associations between physical activity, screen time and weight from 6 to 14 yrs: The Raine Study

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Abstract

To examine the strength and direction of the relationship between physical activity level, screen use and BMI in a cohort at ages 6, 8, 10 and 14 yrs as part of a prospective longitudinal cohort study. The sample comprised 1403 males and females who participated in the follow-up survey at 14 yrs of age between 2003 and 2005. Exploratory structural equation modelling was used to examine the interrelationships between physical activity level, BMI and screen time at 6, 8, 10 and 14 yrs. Predictors of BMI at 6, 8, 10 and 14 yrs explained 1.3, 76.1, 80.1 and 73.1 percent of the variances, respectively, with previous BMI the largest predictor [$\chi^2 = 43.082$, df = 36, $p = 194$]. Increased screen time predicted higher BMI and lower physical activity at 8 and 10 yrs but not 14 yrs. At 14 yrs, physical activity predicted BMI. Sedentary patterns of behaviour in early childhood were predictive of later and concurrent obesity, whereas physical activity was predictive of obesity in adolescence. Different intervention targets are required for children and adolescents.

Keywords: Children; Adolescents; Television viewing; Body Mass Index; Longitudinal; Physical activity

1. Introduction

Numerous cross sectional studies have identified associations between lower levels of physical activity and greater time engaged in sedentary pursuits such as screen time and higher Body Mass Index (BMI) among children and adolescents.[1,2] The strength of the associations are inconsistent which may be due in part to the primary outcome of interest or the age of the cohort. Associations between physical activity, sedentary behaviours such as screen time and weight status differ if cohorts are grouped according to weight (overweight/obese vs acceptable),[1–4] screen use (high vs low),[4,5] and activity (high vs low).[5,6] For example, comparisons of overweight and acceptable weight cohorts found that overweight children and adolescents spent more time engaged in sedentary pastimes, including screen use, and less time involved in sports and other activities compared to their normal weight counterparts.[4,6–8] When grouped according to screen use, the high screen users were more likely to be overweight or obese,[4,5] but not necessarily less physically active.[5,9,10] Finally, when active and inactive cohorts were compared, no relationship was found with weight status[6,11] and mixed results were reported for screen time.[1,5,12]

In order to better understand these associations and the direction of the relationship, longitudinal studies are required. However, to date we have not identified any studies that used longitudinal data from childhood into adolescence to examine the directional relationships between physical activity level, screen time and BMI. Recently, Metcalf et al.[13] reported that obesity leads to physical inactivity using data from a short longitudinal study tracking a cohort of children from 7 to 10

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yrs of age. It is important to determine if this relationship holds true into adolescence. The purpose of this paper was to report on the application of exploratory structural equation modelling (SEM) to examine the interrelationships between BMI, physical activity and screen viewing behaviours in a cohort tracked from childhood (6 yrs) to adolescence (14 yrs) and to contribute to the directionality debate.

2. Methods

The Western Australian Pregnancy Cohort (Raine) Study recruited 2979 pregnant women reporting to antenatal clinics in Perth, Western Australia from 1989 to 1991, which resulted in 2868 live born children.[14] This cohort has since been followed in surveys at 1, 2, 3, 6, 8, 10, and 14 yrs of age and is broadly representative of the Western Australian population.[15]

We based our analyses on the anthropometric and physical activity data for 1403 adolescents who participated in the 14-yr survey. The group comprised 729 males ($M = 14.02$ yrs, $SD = 0.20$) and 674 females ($M = 14.02$ yrs, $SD = 0.19$). Numbers vary for some variables as parents and participants did not participate in all components at each of the earlier follow-ups. Age was calculated from the date of questionnaire completion. For each survey, some participants completed the questionnaires by mail and some attended the Telethon Institute for Child Health Research for physical examinations and to complete questionnaires. The study was approved by the Institutional Ethics Committee.

In order to run an exploratory structural equation model, data for each variable across time must be comparable. Consequently, the data for physical activity and screen time at each follow-up were converted to dichotomous variables using the procedures described below.

Parents reported by questionnaire on their child's physical activity during the 6, 8, and 10-yr follow ups. At 6 yrs, parents answered Yes/No to two questions asking if their child was involved in any organized sport at school or with a club or organized activity such as music, dancing, Kindygym or other clubs. No activity (No to each question) was scored as 0 and one or more activity was scored as 1. At the 8-yr follow-up, parents were asked to rate their child's level of activity as either sedentary or slightly active, which were both coded as 0, or active (involved in an organised activity 2–3 times per week) which was coded as 1. At the 10-yr follow up parents diarised the time in minutes for their child's daily physical activities over a typical week. A total score was derived and participants grouped into the lowest tertile categorized as low active (0) and the others classified as active (1). At the 14-yr follow-up, the participants responded to three questions about time spent exercising vigorously during physical education at school (none, about a quarter of the time, about half the time, more than half the time, to almost all the time), how often they got out of breath or sweated while exercising outside school hours (once a month, once a week, 2–3 times a week, 4–6 times a week, every day) and how many hours they got out of breath or sweated while exercising outside school hours (none, about 1/2 h/week, about 1 h/week, about 2–3 h/week, about 4–6 h/week, 7 or more hours/week). Responses were summed to create a composite variable with a maximum possible score of 13. Participants in the lowest tertile were categorized as low active (0) and the others were classified as active (1).

For the 6, 8 and 10-yr surveys, parents reported on their child's screen time. At 6 and 8 yrs, the six category question asked only about television viewing, and response options ranged from none to more than three hours per day. For the 10-yr questionnaire, a similarly coded question was used, which also asked about time spent watching TV and/or computer games. At 14 yrs, the adolescents responded to two five category questions about the number of hours per day watching TV or videos, and the number of hours per day playing video or computer games. The response options ranged from not at all to 4 h or more per day. These two questions were combined to create overall screen time categories. For each survey, it was possible to categorise the data for participants into those reporting greater than or less than 2 h of screen time. This cut off is based on the Australian recommendations for hours of screen time per day for adolescents.[16]

Extensively trained researchers completed all anthropometric measures. Weight was measured to the nearest 100 g using calibrated Wedderburn digital scales and height was measured to the nearest 0.1 cm with a calibrated Holtain stadiometer. Body Mass Index (BMI) (wt/ht^2) was derived from the height and weight measures taken at each survey.

Analyses were performed using SPSS version 17 (SPSS Inc., Chicago, IL). Gender and adolescent weight status group differences were investigated using *t*-tests and chi-square. Exploratory structural equation modelling (SEM) (AMOS v17) was used to test a longitudinal model of interrelationships between screen time, physical activity and BMI at each time point and across time from 6, 8, 10 to 14 yrs. We hypothesized that each variable would track across time and that the interrelationships between each variable would strengthen with time, with possible lag effects (e.g. screen time at 6 yrs would have a direct effect on physical activity at 6 yrs and lag effects on physical activity at 8, 10 and 14 yrs). Normality was within the recommended limits.[17] Due to the presence of missing data (0–11.2% missing at random), a series mean replacement of missing values was conducted in SPSS to create a complete dataset for single-step model building (adding pathways).[18] This permitted model building to be explored by the addition of theoretically sound pathways based on modification indices.[17] Model building was conducted one pathway at a time, by examining both directions between variables at each time point, and lag effects between variables over time. Directionality of pathways was determined by statistical strength of association based on modification indices. The original dataset (with missing values) was then used for single step model trimming (removing pathways one at a time),[18] with a maximum likelihood estimation procedure.[19] A test