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Interaction of sedentary behaviour, sports participation and fitness with weight status in elementary school children

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Abstract
Even though the effect of single components contributing to weight gain in children have been addressed only limited research is available on the combined association of sports participation, physical fitness and time spent watching TV with body weight in children. Baseline data from 1594 children (809 male; 785 female), 7.1 $\pm$0.6 years of age participating in a large school-based intervention in southern Germany was used. Height and weight was measured and body mass index (BMI) percentiles (BMIPCT) were determined accordingly. Sports participation and time spent watching TV was assessed via parent questionnaire while fitness was determined via a composite fitness test. Combined and single associations of sports participation, TV time and fitness with BMIPCT and weight status were assessed via ANCOVA as well as logistic regression analysis, controlling for age and sex. A significant interaction of TV time, sports participation and fitness on BMIPCT occurred, despite low correlations among the three components. Further, there was a combined association of sports participation and TV time on BMIPCT. TV time and fitness were also independently associated with BMIPCT. Similarly, only increased TV time and lower fitness were associated with a higher odds ratio for overweight/obesity. These results underline the complex interaction of TV time, sports participation and fitness with BMIPCT. In children, TV time and fitness have a stronger influence on BMIPCT compared to sports participation. Sports participation, however, may not reflect overall activity levels of children appropriately. More research is necessary to examine the complex interaction of various behaviours and fitness with BMIPCT.

Keywords: *TV consumption, physical activity, body composition, overweight, youth, obesity*

Introduction

The rising prevalence of overweight and obesity in children and adolescents around the world (Pigeot, Buck, Herrmann, & Ahrens, 2010) has lead the World Health Organization (WHO, 2002) to declare obesity as one of the leading future threats to public health. Of particular concern is that overweight or obese children and adolescents are at increased risk to become overweight adults and develop associated comorbidities such as cardiovascular disease, diabetes or cancer (Daniels, 2006). The increasing number of overweight and obese children has also lead to the occurrence of various cardiovascular and metabolic risks previously only observed in adults (Kim & Lee, 2009; Must & Strauss, 1999). The specific causes of overweight and obesity are complex, but despite the consideration of genetic and physiologic aspects, a reduction in physical activity (PA) and increased caloric intake due to environmental changes seem to be important factors for weight gain (Hill, Wyatt, Reed, & Peters, 2003; Steele, van Sluijs, Cassidy, Griffin, & Ekelund, 2009). In their global recommendations on PA for health the WHO (2010) also emphasised that PA is an independent risk factor for non-communicable diseases. In addition to insufficient PA, increased sedentary behaviour has been shown to influence body composition and health independently (Ekelund et al., 2006; Owen, Healy, Matthews, & Dunstan, 2010). Along with these changes a decline in physical fitness has been observed (Zahner et al., 2009) which has a negative effect on health as well (Micheli et al., 2011).

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Various studies have addressed the relationship between PA, fitness or sedentary behaviour and body composition, but there is a lack of research on the interaction of these components. Further, only a few studies have examined the associations between sports participation, sedentary behaviour and body composition and results have been inconsistent (Quinto Romani, 2011; Zahner et al., 2009). The majority of studies also examined pubertal children rather than a younger cohort. The purpose of this study, therefore, was to examine the combined effects of sports participation, fitness and time spent in sedentary behaviour on body composition in elementary school children.

Methods

Baseline data from a large school-based intervention programme in south-west Germany, collected during fall 2010 was used. A total of 1944 (62.3%) of first- and second-grade students agreed to participate in the study (Dreyhaupt et al., 2012), but only children without any reported chronic disease (i.e. hayfever, neurodermatitis, asthma, etc.) were included in the analysis which reduced the sample size to 1594 (809 male; 785 female) children 7.1 ± 0.6 years of age. Further, not all children had complete data, which lead to a variation in sample size for different analyses. Parental consent as well as child assent were obtained prior to data collection, and the study protocol was approved by the institutional ethics committee. As data presented in this study were collected at baseline, prior to the intervention, the study is considered cross-sectional.

Anthropometric measurements

Height (cm) and weight (kg) was measured according to standard procedures (Malina, 1995) with children wearing gym clothes and no shoes. Specifically, height was measured to the nearest 0.1 kg using calibrated flat scales (Seca model 826, Seca®, Germany) and weight was measured to the nearest 0.1 cm using mobile stadiometers (Seca model 217, Seca®, Germany). Body mass index (BMI) was calculated (kg/m^2) and converted to BMI percentiles (BMIPCT) using Kromeyer-Hauschild et al. (2001) reference values. As recommended by these authors, overweight/obesity was subsequently determined above the 90th percentile.

Health behaviour

The engagement of children in PA and sedentary behaviour was assessed via parental report. As currently no validated instrument for the assessment of health behaviour is available in German, questions used were based on the KiGGS survey, which assessed health behaviour in 18,000 German children and adolescents (Kurth, 2007). Specifically, parents were asked about their child's sports participation (club and non-club), time spent watching TV and playing computer. Due to a possible limitation in access to a computer, and TV being the most common sedentary activity (Gorely, Marshall, & Biddle, 2004), time spent watching TV was used as a proxy for sedentary behaviour. Based on current recommendations, a cut point of watching TV of 60 min/day was used to distinguish between high and low TV consumers (American Academy of Pediatrics, 2005). Sports participation was classified as low (<120 min/week), moderate (120–250 min/week) and high (>250 min/week) using sample tertiles.

Physical fitness

Physical fitness was assessed using six components of the Dordel-Koch-Test fitness test (Graf et al., 2004). Specifically, children performed two trials for sit-and-reach (cm), standing long-jump (cm), 15-sec sideways jumping (number of jumps), sit-ups (number of sit-ups in 40 sec), push-ups (number of push-ups in 40 sec) and one trial for a 6-min run (m). The best score for each test was included in a principal component factor analysis, which yielded a single overall fitness score (Eigenvalue $=2.5$), explaining 41.2% of the total variance. Specifically, factor loadings were 0.25 for sit-and-reach, 0.65 for the 6-min run, 0.66 for push-ups, 0.70 for sit ups, 0.71 for standing long-jump and 0.75 for sideways jumping. This composite fitness score was used as an indicator for overall fitness, and subjects were classified into low, moderate or high fitness groups based on sample tertiles.

Data analysis

After calculating descriptive statistics and checking data for normal distribution partial correlation analysis, controlling for sex and age, was used to examine the relationship between TV time, sports participation, fitness and BMIPCT. A 2 (TV) $\times$3 (Sport) $\times$3 (Fitness) ANCOVA, controlling for sex and age, was used to examine combined associations on BMIPCT. Further, two-way interactions and main effects were examined using Bonferroni adjustments for multiple analyses. In addition, logistic regression was used to assess the association between time spent watching TV, sports participation, fitness and overweight/obesity, again controlling for sex and age. All statistics were performed in Predictive Analysis Software (PASW) 18.0 with a significance level set at $\alpha \leq 0.05$.

Table I. Descriptive characteristics for males, females and the total sample. Values are mean ± SD

	Male (N = 809)	Female (N = 785)	Total sample (N = 1594)
Age (years)	7.1 ± 0.6	7.1 ± 0.6	7.1 ± 0.6
Weight (kg)*	24.9 ± 4.9	24.4 ± 4.8	24.7 ± 4.9
Height (cm)**	124.3 ± 6.4	123.2 ± 6.3	123.8 ± 6.3
BMIPCT	48.3 ± 27.8	48.9 ± 28.0	48.6 ± 27.9
Overweight/obese (%)	13.7	14.1	13.9
TV (min/day)*	55.1 ± 28.5	51.8 ± 28.4	53.4 ± 28.5
Sport (h/week)**	4.7 ± 4.8	3.6 ± 4.5	4.1 ± 4.7
Sit-and-reach (cm)**	0.84 ± 5.5	2.6 ± 5.6	1.7 ± 5.6
Standing long-jump (cm)**	115.5 ± 23.3	109.1 ± 21.3	112.4 ± 22.6
Sideways jumping (# in 30 sec)	40.8 ± 12.8	42.0 ± 13.0	41.4 ± 12.9
Sit-ups (# in 40 sec)**	12.3 ± 6.2	11.6 ± 5.8	12.0 ± 6.0
Push-ups (# in 40 sec)*	5.6 ± 4.1	5.1 ± 4.0	5.3 ± 4.1
6-min run (m)**	872 ± 130	823 ± 110	848 ± 123

*Difference between males and females at $p < 0.05$.
**Difference between males and females at $p < 0.01$.

Results

Descriptive characteristics of the sample are shown in Table I. The prevalence of overweight/obesity was 13.9%. Even though boys were significantly taller and heavier than girls, there was no difference in BMIPCT. Boys participated not only in more sports but also spent more time watching TV compared to girls. Except for the sideways jumping, performance on the fitness tests differed significantly between boys and girls. Boys performed better on the power, strength and endurance tests, while girls displayed a higher flexibility. The composite fitness score was also significantly higher in boys compared to girls.

Partial correlation coefficients, adjusted for age and sex, were generally low. Nevertheless, except for the relationship between sports participation and TV time as well as BMIPCT all correlations were significant (Table II). The three-way ANCOVA, adjusted for sex and age, revealed a significant combined association of TV time, sports participation and fitness on BMIPCT (F (4, 1289) = 2.66; $p = 0.03$). The highest BMIPCT occurred in the low fitness-low sports-high TV group (63.8 ± 31.0) and the lowest BMIPCT was observed in the high fitness-high sports-low TV group (39.9 ± 23.0). Further, TV time and sports participation had a significant combined effect on BMIPCT (F (2, 1365) = 3.13; $p = 0.05$), with the high TV-low sport group displaying significantly higher BMIPCT than the low TV groups (Figure 1). In addition to the combined effects, significant main effects of BMIPCT on TV time (45.1 ± 26.3 vs. 52.2 ± 28.1) and fitness score (F_{TV} (1, 1365) = 20.77; $p < 0.01$ and $F_{Fitness}$ (2, 1505) = 17.90; $p < 0.01$) were observed. All fitness groups differed significantly from each other with the high fitness group displaying the lowest BMIPCT (43.1 ± 25.3) and the low fitness group displaying the highest BMIPCT (54.3 ± 29.7). No significant main effect for sports participation was observed.

Logistic regression analysis resulted in similar findings (Table III). Low fitness as well as high TV time significantly increased the odds for being overweight/obese, while sports participation did not have a significant effect. Watching TV for more than 60 min/day doubled the odds of being overweight/obese compared to those watching < 60 min/day and increasing fitness was associated with a 50% reduction in the odds for overweight/obesity. It should, however, be mentioned that despite being significant (χ^2 (5, $N = 1289$) = 45.07; $p < 0.01$), TV time, fitness, sports participation as well as sex and age only explained between 5.9% (Cox and Snell

Table II. Partial correlation coefficients adjusted for sex and age

	Sport	Fitness score	BMIPCT
TV (min/day)	−0.03	−0.06*	0.15**
Sport (min/week)		0.12**	0.01
Fitness score			−0.19**

*Correlation significant at $p < 0.05$.
**Correlation significant at $p < 0.01$.

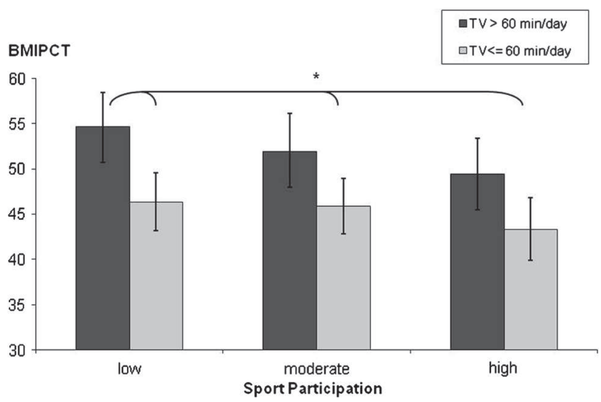

Figure 1. BMIPCT by sports participation and TV time. Values are age and sex adjusted means with 95% confidence interval. *Significant group-difference ($p < 0.05$).

Table III. Odds ratios based on logistic regression for overweight and obesity

	Odds ratio	95% confidence interval
TV time*	2.010	1.341; 3.011
Sports participation	0.948	0.739; 1.215
Fitness*	0.485	0.369; 0.637
Sex	0.841	0.562; 1.260
Age*	1.533	1.120; 2.099

*Significant odds ratio ($p < 0.05$).

R square) and 13.5% (Nagelkerke R squared) of the variance in weight status. Nevertheless, 91.5% of children were classified correctly.

Discussion

The low correlation of sports participation, fitness, TV time and BMIPCT reflects the complex interaction of behavioural factors and body composition. Previous studies also showed relatively low correlations between PA, fitness, sedentary behaviour and body composition (Michaud, Narring, Cauderay, & Cavadini, 1999; Prentice-Dunn & Prentice-Dunn, 2012; Steele et al., 2009). Nevertheless, there was a combined association of all three components on BMIPCT. Further, sports participation and TV time had a combined effect on BMIPCT. TV time was also independently associated with BMIPCT, while no such relationship was shown for sports participation. Jackson, Djafarian, Stewart and Speakman (2009) argue that food intake, rather than displacement of PA or sports, is the mediating aspect between sedentary behaviour and body composition. As a considerable amount of the total energy intake of children is consumed while watching TV (Matheson, Killen, Wang, Varady, & Robinson, 2004) it has been suggested that increased body weight is due to higher caloric intake rather than displacement of sports or PA. In adults, an alteration in fat and glucose metabolism has been shown with increased sitting, which could also lead to increased fat accumulation (Dunstan et al., 2004; Hamilton, Hamilton, & Zderic, 2004) and in children, increased sedentary time was associated with insulin resistance (Sardinha et al., 2008).

The lack of an independent association between sports participation and BMIPCT may also be due to the fact that sports participation is only one aspect in overall PA and may not necessarily reflect the engagement in total PA. Especially younger children engage more in free play rather than structured sports (Salmon, Campbell, & Crawford, 2006). Sports participation was, however, related with fitness, which showed independent association with BMIPCT. Thus, it can be argued that sports participation functions as moderating factor rather than directly affecting BMIPCT. The reported relationship between fitness and BMIPCT has also been reported in children as well as adolescents (Johnson et al., 2000; Kim et al., 2005). Specifically, Kim et al. (2005) pointed out that not only cardiorespiratory fitness, but also abdominal strength, upper body strength and agility was lower in overweight children and adolescents compared to their normal weight peers. These authors further suggest that lower fitness levels increase the risk for weight gain, particularly in girls. In addition, Minck, Ruiter, van Mechelen, Kemper and Twisk (2000) showed that lower fitness levels in adolescents are associated with higher fatness during early adulthood.

There was also a significant but low inverse correlation between fitness and TV time, which has been reported previously as well (Tremblay et al., 2011). This may be due to the fact that increased TV time has been associated with a reduction in vigorous activity (Ara et al., 2006; Marshall, Biddle, Gorely, Cameron, & Murday, 2004) and the lower levels of vigorous PA are related with lower fitness levels in children (Bürgi et al., 2011). As fitness levels have been shown to decrease in school-aged children resulting in an increased metabolic risk independent of weight status, an increase in PA, especially vigorous PA is warranted (Sassen et al., 2009). Sports participation could be one way to increase vigorous PA and subsequently increase fitness but sufficient vigorous habitual PA might be possible as well.

The lack of a relationship between sports participation and BMIPCT is in accordance with Zahner et al. (2009), who did not show an association between club sports participation and body fatness in first- and second- grade children. Other studies, however, did show lower BMI or fat mass in children who display higher sports participation (Ara et al., 2004; Nagel et al., 2009; Quinto Romani, 2011). The sample size of Ara et al. (2004), however, consisted only of boys who display higher sports participation than girls or a mixed sample (Michaud et al., 1999) and they only considered club sports, which may result in more vigorous sports participation. Further, the higher age of participants (Ara et al., 2004; Quinto Romani, 2011) needs to be considered as sports participation is higher in adolescents compared to children (Zahner et al., 2009). Nevertheless, Nagel et al. (2009) did show a significant effect of sports participation on BMIPCT in kindergarten children. The inconsistency with the current study could be explained with a potential bias as parents knew about the purpose of the study due to the planned intervention and, therefore, may not accurately report their children's involvement in sports. Further, the intensity of sports participation was not assessed in the present study.

In addition to the limitation of subjective reports on sports participation as well as sedentary behaviour, the following limitations of the study need to be considered. As mentioned previously, sports participation does not equal PA. It provides only one opportunity for PA but it may be more easily assessed via self report compared to unstructured activities. In younger children, unstructured PA may contribute significantly to their overall activity levels (Zahner et al., 2009). Nevertheless, Ebenegger et al. (2012) did show a direct relationship between sports participation and habitual PA in preschoolers. Further, only TV time was used as proxy for sedentary behaviour. Despite the fact that watching TV is the most common sedentary behaviour (Gorely et al., 2004), this may not accurately reflect total sedentary time. Several other leisure activities such as playing computer games or reading could contribute significantly to total sedentary time. It should also be considered that the sample is not representative of the region as only children whose teachers and parents agreed to participate in a school-based intervention programme were included. Due to the fact that teachers who are part of the intervention agreed to the incorporation of active breaks and information on an active and healthy lifestyle in their curriculum, it is possible that these teachers emphasised a more active classroom even prior to the study, and, therefore, activity levels of these children may have been higher than the average population. The relatively low prevalence of overweight and obese subjects in the sample is also indicative of a healthier cohort. In addition, other constraints influencing health behaviour and BMIPCT, like socio-economic status and access to facilities promoting an active lifestyle was not considered in the analysis (Stalsberg & Pedersen, 2010). Finally, the cross-sectional design of the study does also not allow to establish causal relationships between body weight and fitness or TV time. It could be possible that children who are inherently more fit would display a lower BMIPCT and, therefore, engage in less sedentary behaviour rather than sedentary behaviour causing increased body weight.

Conclusion

Despite these limitations, this study does provide additional insight into the role of sedentary behaviour, sports participation and fitness on BMIPCT and shows the combined association of these components on body composition. It supports previous findings showing increased risk of overweight/obesity with lower fitness and higher TV time in a young sample and underlines the necessity for an early acknowledgement of a healthy lifestyle. The lack of an effect of sports participation may support the necessity of habitual PA, especially in a younger sample or a potentially more vigorous engagement in sports may be necessary to affect body composition. Due to the complex relationships between sports participation, fitness and sedentary behaviour more research is needed, using objective measurements, to examine the combined association of behavioural factors and physiologic components on children's body composition and health. Additionally, a longitudinal assessment of these factors is warranted to establish causal relationships between PA, sedentary behaviour, fitness and body composition as current evidence is only moderate at best (Chinapaw, Proper, Brug, van Mechelen, & Singh, 2011). A better understanding of the causal interaction between behavioural factors, physiologic constraints and body composition is necessary for the development of appropriate intervention strategies to address the growing problems associated with the high prevalence of overweight children and adolescents.

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