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Correlates of weight gain in German children attending elementary school

Clemens Drenowatz *, Susanne Kobel, Sarah Kettner, Dorothea Kesztyüs, Tamara Wirt, Jens Dreyhaupt, Jürgen M. Steinacker

Ulm University Medical Center, Division of Sport and Rehabilitation Medicine, 89075 Ulm, Germany

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ABSTRACT

Objective. To examine the association of physical fitness, sports participation, physical activity and sedentary behavior as well as dietary patterns and family background with weight gain in non-overweight elementary school children, independent of absolute body weight.

Methods. Height, weight, and physical fitness were assessed in 1249 (51% male) children in south-west Germany during the fall of 2010 and 2011 (age at baseline: 7.0 ± 0.6 years). Based on changes in body mass index percentiles children were classified into a weight loss, constant weight, or weight gain group. Health behavior and family background were assessed via parent questionnaire. Group differences were examined via analysis of variance and multinomial logistic regression.

Results. Weight gain was associated with low physical activity, lack of active transport, and lack of regular breakfast at follow-up. Children in the weight gain category also displayed lower fitness during baseline and follow-up, but differences were more pronounced during follow-up. TV time, migration background or parental education was not associated with weight gain.

Conclusion. Ensuring adequate physical activity and high fitness is an important aspect in the prevention of excessive weight gain during childhood. In addition to sports participation active transport should be emphasized in future weight management programs in children.

Introduction

The high prevalence of overweight and obesity in children and adolescents has been declared as one of the leading future threats to public health as excessive body weight is associated with various adverse health consequences and metabolic diseases (Lobstein et al., 2004; World Health Organisation, 2002). In addition there is an increased risk for overweight children for several psychological and social repercussions and orthopedic problems (Lobstein et al., 2004; Reilly et al., 2003), which impair overall quality of life (Wardle and Cooke, 2005; Wille et al., 2008). Childhood overweight and obesity has been described as a complex phenotype that is influenced by a genetic predisposition, environmental and socio-demographic factors as well as modifiable lifestyle factors (Dupuy et al., 2011). Particularly, low socio-economic status (Wang and Lim, 2012), low levels of physical activity (PA), increased sedentary behaviors (i.e. watching TV, playing video games), skipping breakfast, and high intake of sugar-sweetened beverages have been associated with obesity during childhood and adolescence (de Vet et al., 2011; Haug et al., 2009; Monasta et al., 2010). Most studies, however, predominantly looked at differences between children of different weight categories. Only limited research is available on associations between different behaviors and the process of weight gain even though prevention of excessive weight gain has been proposed as the only feasible solution to address the global obesity epidemic (Lobstein et al., 2004).

The increase in body weight is particularly pronounced at early elementary school age (Hoffmann et al., 2012) and it has been shown that elementary school children with a BMI above the 50th percentile are already at an increased risk for overweight or obesity during adolescence and adulthood (Field et al., 2005). Therefore, effective strategies to prevent excessive weight gain in normal weight children are needed. A better understanding of correlates of weight gain in non-overweight children should facilitate the development of appropriate intervention programs. The purpose of this study was to examine the association of physical fitness, sports participation, PA and sedentary behavior as well as dietary patterns and family background (i.e. parental education, migration status) with weight gain, independent of absolute body weight, in non-overweight elementary school children.

Materials and methods

Study design

Data collection occurred during fall 2010 and fall 2011 in southwest Germany. Details of the study design and sample stratification have been described previously (Dreyhaupt et al., 2012). In brief, schools were recruited

* Corresponding author at: Ulm University Medical Center, Division of Sport and Rehabilitation Medicine, Frauensteige 6, 89075 Ulm, Germany.
E-mail address: clemens.drenowatz@uni-ulm.de (C. Drenowatz).

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via advertisements in seminar catalogs for elementary school teachers, electronic newsletters and information on local television and radio. This allowed for recruitment throughout the entire state of Baden-Württemberg. Upon the agreement of the school and the respective classroom teacher, parents received information about the study by mail and provided informed consent for their child. Child assent was obtained prior to data collection on the day of measurement. The study was approved by the institutional review board and is in accordance with the Declaration of Helsinki. Data collection was performed in similar manner during baseline and follow-up with 1494 elementary school children providing data during both measurement times. After excluding children with reported chronic disease and those being overweight or obese at baseline 1249 (635 male, 614 female) first- and second-grade students remained for data analysis. As not all children provided complete data on the parent questionnaire (i.e. parents refused to answer specific questions) and some did not complete all tasks on the fitness test, sample size varied for individual analyses.

Anthropometric measurements

Children's height and weight as well as their physical fitness were assessed by trained technicians during a school visit. Height (cm) was measured to the nearest 0.1 cm using mobile stadiometers (Seca model 217, Seca ®, Germany) and weight was measured to the nearest 0.1 kg using calibrated flat scales (Seca model 826, Seca ®, Germany) with children wearing only underwear. Body mass index was calculated (kg/m^2) and converted to BMI percentiles (BMIPCT) using German reference values (Kromeyer-Hauschild et al., 2001). Weight change was calculated by subtracting baseline values from follow-up values. Based on the sample distribution a reduction or increase in BMIPCT by a value of more than 5 was utilized to differentiate between children in the weight loss or weight gain group, respectively. Children with a BMIPCT change of equal or less than 5 were classified as maintaining a constant weight.

Fitness test

Physical fitness was assessed using 5 components of the DKT (Dordel–Koch-Test) fitness test (Graf et al., 2004) after anthropometric measurements. Children performed two trials for standing long-jump (cm), 15-sec sideways jumping (number of jumps), sit-ups (number of sit-ups in 40 s), push-ups (number of push-ups in 40 s), and one trial for a 6-minute run (m). Principal component factor analysis revealed a single score with an Eigenvalue greater than 1. The fitness score explained 49.2% of the total variance (Eigenvalue = 2.5) at baseline. At follow-up the principal component analysis yielded a single fitness factor explaining 49.9% of the total variance (Eigenvalue = 2.5).

Health behavior

Additional correlates of weight gain were assessed via parent questionnaire. Questions were based on the German Health Interview and Examination Survey for Children and Adolescents (KiGGS), which assessed health behavior in 18,000 German children and adolescents (Kurth, 2007). Questionnaires were sent to the parents upon completion of the measurements during the school visit. Parents were asked to complete the questionnaire within a period of three weeks and return the questionnaire to the data center in a pre-paid envelope. Children's organized and habitual sports participation, the number of days children achieved at least 60 min of moderate-to-vigorous PA (MVPA), time spent walking and playing outside per day were reported. Further, parents were asked how often their children had breakfast prior to going to school as well as the amount of sugar-sweetened beverages consumed per week. Parental report on the child's TV time was used as a proxy for sedentary behavior. As the American Academy of Pediatrics, Committee on Public Education (2001) recommends less than 1 to 2 h of total media time per day a cutpoint of 60 min/day for watching TV was used. In addition parents reported their educational status and whether they were born in Germany along with the primary language spoken at home. Children were classified as having a migration background when at least one parent was born outside Germany or the predominant language at home was not German. Parents also reported their own height and weight, which were used to calculate BMI (kg/m^2).

Statistical analysis

Differences between the weight loss, constant weight, and weight gain groups were examined separately at baseline and follow-up. MANCOVA, controlling for sex and BMIPCT, was used to examine differences in individual fitness components, while ANCOVA, also adjusting for sex and BMIPCT, was used to examine differences in sports participation and overall fitness. Changes over time in sports participation and fitness were examined via dependent *t*-test. The questionnaire data was analyzed via multinomial logistic regression analysis. Odds ratios were calculated individually as well as after including all correlates in a single model, again controlling for sex and BMIPCT. Significant results were further analyzed for boys and girls separately. All statistics were calculated using SPSS 19.0 with a significance level set at $\alpha \le 0.05$ using Bonferroni adjustment for multiple analyses.

Results

Examining changes in BMIPCT, roughly 25% of the participants reduced their BMIPCT by more than five percentiles and almost 30% increased their BMIPCT by more than five percentiles. Descriptive statistics for the 3 groups at baseline are shown in Table 1. There was no difference in BMIPCT between the weight gain and weight loss group, but children in the constant weight group displayed significantly lower BMIPCT values (F (2, 1247) = 14.10, $p < 0.01$). As expected, BMIPCT were significantly higher in the weight gain group at follow-up (F (2, 1247) = 81.90, $p < 0.01$) and 26 children in the weight gain group (7.2%) were classified as being overweight or obese at follow-up (Table 2). Parents of the weight gain group also displayed a higher BMI (F_{Mom} (2, 1094) = 8.90, $p < 0.01$; F_{Dad} (2, 1025) = 3.85, $p = 0.02$). In the sex specific analysis, however, only maternal BMI remained significantly higher in the weight gain group compared to children who maintained or lost weight (F_{boys} (2, 633) = 4.57, $p = 0.01$; F_{Girls} (2, 612) = 4.44, $p = 0.01$).

Regarding sports participation, no group differences occurred at baseline. Dependent t-tests for the total sample showed a decline in habitual sports participation from baseline to follow-up (t (1248) = 2.13, $p = 0.03$), while participation in organized sports increased (t (1248) = −5.78, $p < 0.01$). Children in the weight loss group, however, maintained their habitual sports levels (t (329) = 0.45, $p = 0.65$), which resulted in a significantly higher habitual sports participation at follow-up compared to the other two groups, even after controlling for sex and BMIPCT (F (2, 1244) = 4.37; $p = 0.01$). In the sex specific analysis, a higher participation in habitual sports was observed

Table 1
Descriptive statistics at baseline (collected during fall 2010 in southwest Germany). Values are mean ± SD.

	Weight loss N = 330, 51% male	Constant weight N = 559, 50% male	Weight gain N = 360, 52% male
Age (years)	7.0 ± 0.6	7.0 ± 0.6	7.1 ± 0.6
Height (cm)[a)]	123.1 ± 6.2	123.1 ± 6.2	124.1 ± 5.9
Weight (kg)[b)]	23.9 ± 3.4	23.2 ± 3.6	24.0 ± 3.1
BMIPCT[b)]	48.1 ± 21.5	39.6 ± 25.9	45.1 ± 22.7
Mom BMI[c)]	23.5 ± 4.1	23.4 ± 3.7	24.6 ± 4.6
Dad BMI[d)]	25.7 ± 3.2	26.1 ± 3.5	26.5 ± 3.6
Migration background (%)	22.9%	19.4%	24.7%
Habitual sports (min/week)	232.6 ± 215.1	214.8 ± 186.4	236.7 ± 218.2
Organized sports (min/week)	100.2 ± 100.9	96.4 ± 95.5	86.2 ± 90.0
Sit-ups in 40 s[a)]	12.5 ± 5.7	12.7 ± 5.9	11.5 ± 5.9
Push-ups in 40 s	5.2 ± 3.8	5.8 ± 4.2	5.4 ± 4.3
6-min run (m)[a)]	863.5 ± 123.9	870.6 ± 111.5	848.8 ± 113.5
Standing-long jump (cm)	114.0 ± 21.6	114.8 ± 21.6	112.0 ± 23.0
Sideways jumps in 30 s[b)]	40.7 ± 12.2	43.6 ± 13.2	41.1 ± 13.2

Significant differences based on ANOVA (Bonferroni adjustment for post hoc test, $p < 0.05$).
[a)] Constant weight group sig. different from weight gain group.
[b)] Constant weight group sig. different from other two groups.
[c)] Weight gain group sig. different from other two groups.
[d)] Weight loss group sig. different from weight gain group.

Table 2
Descriptive statistics at follow-up (collected during fall 2011 in southwest Germany). Values are mean ± SD.

	Weight loss N = 330, 51% male	Constant weight N = 559, 50% male	Weight gain N = 360, 52% male
Age (years)	8.0 ± 0.6	8.0 ± 0.7	8.1 ± 0.6
Height (cm)	129.3 ± 6.6	129.2 ± 6.4	130.1 ± 6.0
Weight (kg) [a)]	25.9 ± 3.7	26.1 ± 4.2	28.4 ± 4.1
BMIPCT [a)]	37.1 ± 20.8	39.5 ± 26.1	57.7 ± 23.1
Habitual sports (min/week) [b)]	231.7 ± 189.5	182.2 ± 160.6	194.5 ± 172.3
Organized sports (min/week)	109.3 ± 102.0	117.1 ± 109.5	100.2 ± 104.2
Sit-ups in 40 s [c)]	15.3 ± 5.5	15.4 ± 5.7	14.4 ± 5.9
Push-ups in 40 s	7.3 ± 4.2	7.5 ± 4.5	7.1 ± 4.3
6-min run (m) [a)]	938.1 ± 122.3	942.2 ± 126.7	905.6 ± 128.1
Standing-long jump (cm) [c)]	125.8 ± 20.0	127.4 ± 19.4	122.8 ± 19.4
Sideways jumps in 30 s [c)]	53.2 ± 11.9	54.5 ± 12.4	52.0 ± 12.5

Significant differences based on ANOVA (Bonferroni adjustment for post hoc test, $p < 0.05$).
[a)] Weight gain group sig. different from other two groups.
[b)] Weight loss group sig. different from constant weight group.
[c)] Constant weight group sig. different from weight gain group.

in boys only ($F (2, 682) = 6.01$, $p < 0.01$) while no differences were observed for participation in organized sports for either boys or girls.

Physical fitness was already lower in the weight gain group at baseline, even after controlling for sex and BMIPCT ($F (2, 1173) = 4.23$, $p = 0.02$). Differences in fitness became more pronounced and remained significant after controlling for sex and BMIPCT at follow-up ($F (2, 1226) = 8.18$; $p < 0.01$). The sex specific analysis revealed differences in fitness only in girls during follow-up ($F (2, 606) = 4.12$; $p = 0.02$), which remained significant even after controlling for baseline fitness in addition to BMIPCT ($F (2, 606) = 3.83$, $p = 0.02$).

Multinomial logistic regression did not show any differences in various behavioral and family correlates at baseline (Table 3). At follow-up, increased odds for weight gain were observed with a lack of regular breakfast consumption and lower levels of MVPA. The weight loss group was more likely to engage in habitual sports for 150 min per week and walk for more than 30 min per day compared to the constant weight and weight gain groups (Table 4). The higher odds for walking and habitual sports participation remained significant when all variables were included in a single model, which explained between 14.3% (Cox and Snell R^2) and 16.2% (Nagelkerke R^2) of the variance in weight change. Consumption of sugar-sweetened beverages, time spent watching TV, as well as parental education and migration background were not significantly associated with increased odds for weight gain in these children. Results were similar in the sex specific analysis

Table 3
Odds ratio [95% confidence interval], adjusted for sex and BMIPCT at baseline. Data was collected in the fall 2010 in the state of Baden-Württemberg in Southwest Germany.

	Constant weight vs. weight loss [95% CI]	Weight gain vs. weight loss [95% CI]
Regular softdrink consumption	0.85 [0.64; 1.14]	1.01 [0.74; 1.39]
No regular breakfast	1.05 [0.79; 1.39]	0.92 [0.68; 1.25]
Club sport participation (<90 min/week)	1.11 [0.84; 1.46]	1.24 [0.92; 1.68]
Habitual sport participation (<150 min/week)	0.83 [0.57; 1.20]	0.74 [0.50; 1.12]
MVPA (= < 3 days)	0.98 [0.73; 1.32]	0.89 [0.64; 1.22]
Walking time (<30 min/day)	1.33 [0.99; 1.78]	1.19 [0.87; 1.63]
Play outside (<60 min/day)	0.85 [0.62; 1.16]	1.05 [0.75; 1.47]
TV (>60 min/day)	0.97 [0.66; 1.43]	1.28 [0.85; 1.89]
Migration background	0.81 [0.57; 1.15]	1.10 [0.76; 1.59]
Mom education (less than high school graduate)	1.12 [0.83; 1.52]	0.96 [0.69; 1.33]
Dad education (less than high school graduate)	0.87 [0.65; 1.18]	1.14 [0.81; 1.60]

Odds ratios were derived via multinomial logistic regression analysis.

Table 4
Odds ratio [95% confidence interval], adjusted for sex and BMIPCT at follow-up. Data was collected in the fall 2011 in the state of Baden-Württemberg in Southwest Germany.

	Constant weight vs. weight loss [95% CI]	Weight gain vs. weight loss [95% CI]
Regular softdrink consumption	0.81 [0.61; 1.09]	0.94 [0.68; 1.32]
No regular breakfast	1.00 [1.00; 1.00]	**1.04** [**1.03**; **1.04**]
Club sport participation (<90 min/week)	0.96 [0.73; 1.27]	1.26 [0.92; 1.72]
Habitual sport participation (<150 min/week)	**1.77** [**1.23**; **2.54**]	**1.75** [**1.14**; **2.68**]
MVPA (= < 3 days)	1.26 [0.94; 1.70]	**1.54** [**1.09**; **2.16**]
Walk (<30 min/day)	**1.54** [**1.09**; **2.18**]	**1.53** [**1.03**; **2.31**]
Play outside (<60 min/day)	1.16 [0.85; 1.58]	1.02 [0.71; 1.46]
TV (>60 min/day)	0.93 [0.64; 1.33]	1.11 [0.74; 1.67]

Odds ratios were derived via multinomial logistic regression analysis with significant results shown in bold.

for girls, while in boys only habitual sports participation increased the odds for weight loss.

Discussion

To our knowledge, this is the first study that examined correlates of weight gain at baseline and follow-up to determine possible precursors and consequences of weight gain independent of absolute body weight in a normal weight sample of elementary school children. The results indicate that weight gain is associated with higher parental weight but not necessarily with migration background or parental education. Low physical fitness was associated with weight gain, particularly in girls, while the association between weight gain and sports participation was more pronounced in boys. A lower fitness level, was already observed at baseline in the weight gain group, which suggests that low fitness is a precursor of weight gain. Sports participation, on the other hand, differed only at follow-up, which would indicate that sports participation is a consequence of increased body weight. Regular breakfast consumption at follow-up reduced the odds for weight gain as well while no association between time spent watching TV or consumption of sugar-sweetened beverages and weight gain was observed in the present study.

The association between increased parental body weight, particularly maternal weight, and a higher risk for overweight in children has been addressed previously (Strauss and Knight, 1999; van Stralen et al., 2012). While a genetic predisposition needs to be considered, the shared environment along with exposure to food and eating habits during early childhood affects children's body weight as well (Kral and Rauh, 2010). Regular breakfast has also been shown to reduce the risk of overweight and obesity in children (Affenito, 2007; Szajewska and Ruszczynski, 2010) and providing breakfast could be an indicator of an increased health consciousness in parents. Parents, who are providing breakfast for their children may be more likely to support other health-related behaviors of their children such as providing logistic support to facilitate PA in their children (Verloigne et al., 2012). The inverse relationship between PA and body weight has been shown by several studies (Haug et al., 2009; Janssen et al., 2005; Kreuser et al., 2013) and results of the present study indicate that participation in habitual sports and active transportation is associated with weight change. Faulkner et al. (2009) addressed the importance of active transportation on total PA and the positive effect on children's body weight. Based on the results of the present study it could be argued that an attenuation of the age-related decline in PA, which is particularly pronounced at the age of school entry (Trost et al., 2002), may already be sufficient to protect against excessive weight gain. The stronger effect in boys may be due to the higher habitual PA levels in boys compared to girls (Trost et al., 2002).

Participation in organized sports, on the other hand, was not associated with changes in BMIPCT. This may be explained by the lack of information on intensity and actual exercise time during training. Sacheck et al. (2011), for example, reported that 9-year-old girls were sedentary for almost 50% of a soccer match. Further, it has been argued that the exposure to organized sports has not been sufficient in younger children to result in significant effects (Kjønniksen et al., 2009). The increase in participation in organized sports from baseline to follow-up suggests that organized sports may become more important with increasing age. In a sample of older children a significant reduction in BMI with increased participation in organized sports was shown (Quinto Romani, 2011). The reliance on changes in BMIPCT rather than measures of body composition, such as % body fat could also contribute to the current results as a loss in fat mass, due to increased sports participation, may be offset by increased muscle mass. Zahner et al. (2009), however, did not report any association between body fatness and sports participation in children of similar age.

Physical fitness, on the other hand, has been associated with participation in organized sports in children and adolescents (Michaud et al., 1999; Zahner et al., 2009). Further an inverse relationship between fitness and body weight has been shown (Kim et al., 2005; Ortega et al., 2008). Results of the present study indicate that low fitness is a precursor of weight gain rather than a consequence of increased body weight which has been already reported in adolescents (Aires et al., 2010a; Minck et al., 2000). Aires et al. (2010a) reported that least fit adolescents gained more weight and lower fitness during adolescence has been associated with increased fatness in young adults (Minck et al., 2000). In addition to an attenuation in weight gain a protective metabolic effect of fitness has been suggested (Stratton et al., 2007) with an inverse association between fitness and various cardiovascular risk factors already observed in children and adolescents (Ortega et al., 2008). Even though there is a genetic predisposition to high fitness levels, engagement in PA, particularly vigorous PA, seems to be the primary factor to increase fitness (Aires et al., 2010b; Ortega et al., 2008).

Increased screentime has been associated with lower fitness (Aggio et al., 2012) and there is a direct association between sedentary behavior and body weight (Prentice-Dunn and Prentice-Dunn, 2012). In the present study, however, no significant association between TV time and weight gain was shown. These results could indicate that increased TV time is a result of increased body weight rather than a contributing factor to weight gain. It has also been argued that food intake while watching TV rather than displacement of PA contributes to increased body weight (Jackson et al., 2009) and children could display high activity levels and report high TV time. Further, TV time is only a proxy for sedentary behavior and may not reflect overall inactivity even though Gorely et al. (2004) argue that watching TV is the most common sedentary behavior. The reliance on parental report could contribute to misrepresentation as well. Parents may not be fully aware of the TV habits of their children or may provide a biased report due to the negative associations with increased TV time. Even though PA was also assessed via parental report, the utilization of various components contributing to total PA in children may allow for a more accurate report. Despite the reliance on subjective assessment of health behavior, this study provides valuable insights into correlates associated with weight gain in normal-weight children independent of body weight. The low odds ratios along with the low explanatory values on variation in weight gain, however, re-emphasize the complexity of behavioral components that are associated with weight gain.

Conclusions

In order to address the health problems and increasing economic burden associated with excessive body weight an increased understanding of the process of weight gain is warranted. As body weight tracks from childhood throughout adolescence into adulthood, intervention programs should be implemented at young ages (Boreham et al., 2004). Based on the present results, the promotion of PA and physical fitness should be emphasized. With an early acknowledgment of an active lifestyle it may actually be sufficient to focus on maintaining current PA levels rather than trying to increase PA later in life. The engagement in sufficient PA, particularly vigorous PA, will also have a positive effect on fitness, which attenuates excessive weight gain and reduces the risk of chronic disease (Ortega et al., 2008). In order to increase the understanding of causal relationships between weight gain and health behavior more longitudinal studies, however, are necessary. Most likely the relationship between body weight and fitness, PA or sedentary behavior is bi-directional, which would re-emphasize an early acknowledgment of a healthy body weight and active lifestyle.

Conflict of interest statement

The authors declare that there is no conflict of interest.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at http://dx.doi.org/10.1016/j.ypmed.2013.06.004.

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