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Physical Activity, Physical Fitness Levels, Daily Energy Intake and Some Eating Habits of 11-Year-Old Children

Marjeta Kovač[1], Janko Strel[1], Gregor Jurak[1], Bojan Leskošek[1], Saška Dremelj[1], Petra Kovač[2], Marjeta Mišigoj-Duraković[3], Maroje Sorić[3] and Gregor Starc[1]
[1]Faculty of Sport, University of Ljubljana,
[2]University Medical Centre Ljubljana,
[3]Faculty of Kinesiology, University of Zagreb

Abstract

The aim of this study was to analyse the relationships between energy intake, energy expenditure (physical activity), physical fitness, body mass index and certain eating habits (breakfast and snacks after 8 p.m.) of 11-year-old children.

A cluster sample of 72 children (35 boys and 37 girls), aged 11.8 (±0.3) years was used for this purpose. The measurements took place during two weekdays and two weekend days. Physical activity (energy expenditure) was assessed with multiple-sensor body monitors (SenseWear Armband; BodyMedia Inc., Pittsburgh, PA, USA). Energy intake and frequency of breakfast and snacks after 8 p.m. were assessed using a self-report questionnaire (My Pyramid Tracker Tutorial; USDA, Center for Nutrition Policy and Promotion, USA). Physical fitness levels were evaluated according to the results of the tests: sit-ups, bent arm hang, 600 m run and 20 m endurance shuttle-run using the Eurofit protocols and peak VO_2, which was measured with a Cosmed K4b2 portable gas analyser. A Pearson correlation coefficient was used to test the correlations between observed variables, and a multivariate analysis of variance was used to test the influence of certain eating habits (breakfast – regular and occasional; snacks after 8 p.m. – occasional and never) on physical fitness according to sex and age. Mann-Whitney test was used to analyse the differences in in the central tendency between boys and girls.

The results show that boys and girls, especially those with increased BMI, reported a one-third lower intake than reported in other studies. Girls were less physically active

than boys. In both groups, the physical activity levels were higher during the week than on weekends, but the energy intakes were higher during the weekends. There were no statistically significant correlations between BMI and physical activity levels. BMI was significantly associated with all selected tests of physical fitness except the sit-ups test. The relationship between the frequency of the two observed meals, physical fitness and sex of the children was negligible.

We can conclude that the assessment of energy intake using a self-report questionnaire is problematic in this age group, especially among those with higher BMI. The measurements of physical activity levels showed that children should be more active during weekends.

Key words*: BMI; breakfast; energy expenditure; evening snack; lifestyle of children; weekdays; weekends*

Introduction

There is little doubt that the extensive changes in lifestyles and the use of modern technology also influence the physical development of children and youth (Ferreira et al., 2007; Ortega et al., 2011; Pušnik & Starc, 2008; van Der Horst et al., 2007). Poor eating habits and a lack of physical activity result in the growth of excess weight and obesity (Daniels et al., 1999; Hills, Andersen, & Byrne, 2011; Olds et al., 2011; Steinbeck, 2001) that are reaching epidemic proportions in the developed world (Garnett, Baur, & Cowell, 2011; Ogden et al., 2012; Starc & Strel 2010; Starc & Strel 2011; Vuorela, Saha, & Salo, 2011).

Obesity is a multifactorial disease with a complex etiology (WHO, 2011) that has many health (Lobstein, Baur, & Uauy, 2004; Khang & Lynch, 2011), social and psychological consequences (Lobstein et al., 2004; Storch et al., 2007).

Overweight and obese children have a greater risk of becoming overweight or obese young adults (Whitaker et al., 1997; Angbratt et al., 2011; Starc & Strel, 2010). The mechanism for developing obesity is not fully understood, however, it is believed to be a disorder with multiple causes. It is confirmed that obesity occurs when energy intake exceeds energy expenditure, suggesting that a proper diet and physical activity are the key strategy for controlling the current epidemic of obesity (Dehghan, Akhtar-Danesh, & Merchant, 2005). Genetic factors influence the susceptibility of a given child to an obesity-conducive environment. However, environmental factors, lifestyle preferences, and the cultural environment seem to play the major roles in the growing prevalence of obesity worldwide (Ferreira et al., 2007; Stamatakis, Wardle, & Cole, 2010; Steinbeck, 2001).

Risk factors for developing obesity may occur as early as in pregnancy, with the diet and lifestyle of the mother (Boer-Boonekamp, L'Hoir, Stam, & Beltman, 2005). During childhood, the variability of dietary practices has increased. The difference in the quantity and quality of food consumed and the regularity and number of meals is very high between different groups of young people, particularly among different

social strata (Alexy, Sichert-Hellert, & Kersting, 2002; Brettschneider & Naul, 2007, Gillis, 2003; Gabrijelčič Blenkuš, Gregorič & Fajdiga Turk, 2007; Popkin, Duffey, & Gordon-Larsen, 2005). Differences in nutrition also exist among children of normal- and overweight parents and among children with different degrees of physical activity: the nutrition pattern deteriorates with the increasing weight of the parents and an increasing degree of inactivity (Alexy et al., 2002; Gillis, 2003).

The mean energy intake of children has declined over the last five decades and excessive weight has been on the increase (Andersen, Froberg, Kristensen & Moller, 2007). Children mostly obtain extra calories from energy-rich snacks that are eaten outside the home, in fast-food stands (Alexy et al., 2002; Gillis, 2003).

The other side of the energy balance equation is decreased physical activity (Spiegelman & Flier, 2001). The level of physical activity among pubertal children decreases with age; boys are still more active than girls, and children from families with high-level socio-status are more physically active than their counterparts from families with lower incomes (Andersen et al., 2007; Brettschneider & Naul, 2007; Ferreira et al., 2007; Strel, Kovač, & Jurak, 2007).

The question whether children are more active during the week or at weekends remains unresolved, at least regarding primary school children, with some studies showing that children are more active on weekdays than at weekends (Rowlands, Pilgrim, & Eston, 2008; Sorič & Mišigoj-Duraković, 2010; van Sluijs et al., 2008) and others reporting higher levels of activity at weekends (Trost, Pate, Freedson, Sallis, & Taylor, 2000).

The home environment has been identified as a key influence on the diet and physical activity of children. The formative childhood years are crucial for the development of health behaviours and health outcomes that continue through adulthood (Kumanyika, 2008; Kumanyika, Parker, & Sims, 2010). The aim of this study was to assess the energy intake and expenditure (the physical activity), the physical fitness, the BMI and certain eating habits (breakfast and snacks after 8 p.m.) of 11-year-old children.

Methods

Participants

Participants were recruited from six primary schools in Ljubljana, Slovenia. The schools were selected through convenience sampling from six different districts of the city with the intention of including various types of urban environments. All children attending A and B classes of the fifth grade of selected schools, aged 10.5–11.5 years, were invited to participate in the study. Having fully informed the schools, the PE teachers, the children and their parents about the aims of the study, its protocol and the possible hazards and discomforts related to the procedures used, written consent was obtained from the parents of all participants. Moreover, the children

gave their verbal assent and were free to withdraw from the study at any time. The study protocols were approved by the Ethics Committee of the Faculty of Sport of the University of Ljubljana.

Forty-four children were excluded from the analysis (38% drop-out) due to inadequate amounts of data, while for other children missing values were imputed using an EM algorithm. Thus, the sample consisted of 72 children (35 boys and 37 girls), aged 11.8 (±0.3) years.

Measurements

The qualified personnel conducted the testing sessions, with testing held in the morning (between 8 a.m. and 2 p.m.) in primary schools' sports halls as part of compulsory PE classes. Subjects were measured in May, 2006. The testing sessions were structured so that following a brief (ca. 10 min) warm-up, the tasks were performed randomly. Subjects were weighed barefoot in their shorts and T-shirts with pre-calibrated portable medical balance scales of various brands to the nearest 0.1 kg. Body height was taken to the nearest 0.1 cm using an anthropometer (GPM; Siber-Hegner & Co., Zurich, Switzerland). Body mass index (BMI) was calculated from body weight and height as weight (in kg) divided by squared height (in m). Physical fitness levels were evaluated by results of tests: sit-ups, bent arm hang, 600 m run and 20 m endurance shuttle-run using Eurofit protocols (Eurofit, 1993) and peak VO_2, which was measured using a Cosmed K4b2 portable gas analyser.

The energy expenditure was assessed by multiple-sensor body monitors (SenseWear Armband; BodyMedia Inc., Pittsburgh, PA, USA). The body monitor was attached to the back of the subject's upper right arm, over the triceps muscle halfway between the acromion and olecranon processes. The subject's gender, age, height, weight and handedness were programmed into the body monitor before it was activated. Children were instructed to wear the armbands during the entire day for four consecutive days (including two weekdays and both weekend days), except during bathing or other water activities. For the purpose of this study, total daily energy expenditure was obtained. The average energy expenditure was calculated for both weekdays and weekend days.

The energy intake and frequency of breakfast and snacks after 8 p.m. were assessed using a self-report questionnaire (My Pyramid Tracker Tutorial; USDA, Center for Nutrition Policy and Promotion, USA) during two weekdays and one of the weekend days. For weekdays, the average energy intakes were calculated.

Data Analysis

Data were analysed using the SPSS 18.0 statistical package. A Pearson correlation coefficient was used to test the correlations between BMI and observed variables and multivariate analysis of variance was used to test the influence of certain eating habits (breakfast – regular and occasional; snacks after 8 p.m. – occasional and never) on physical fitness according to sex and age. Mann-Whitney test was used to analyse the differences in the central tendency between boys and girls.

Results

Physical Fitness

Table 1. *Results of physical fitness tests according to sex*

		BMI	Sit-ups (rep/60 s)	Bent arm hang (s)	600 m run (s)	20 m endurance shuttle run (s)	Peak VO_2 (l/min)
Boys (N=35)	M (SD)	19.02 (3.30)	39.37 (8.19)	35.87 (25.30)	157.83 (21.78)	327.31 (71.01)	48.35 (7.85)
Girls (N=37)	M (SD)	18.33 (3.84)	43.77 (8.02)	43.98 (25.93)	151.99 (19.43)	321.37 (62.92)	46.51 (5.21)
p		0.650	0.059	0.037	0.026	0.002	0.009

The physical fitness of boys and girls is presented in Table 1. There are significant sex differences in 20 m endurance shuttle run test, peak VO_2 ($p < 0.01$), 600 m run and bent arm hang ($p < 0.05$).

The Energy Intake and Expenditure

Table 2. *The energy intake and energy expenditure during the weekdays and weekends according to sex*

Sex / day	N	Energy intake M (SD)	Energy expenditure M (SD)
Boys, weekdays	35	1,372.68 (417.51)	2,243.86 (576.48)
Boys, weekend days	35	1,514.64 (564.59)	2,131.16 (611.73)
Girls, weekdays	37	1,371.74 (412.18)	1,949.14 (434.61)
Girls, weekend days	37	1,403.60 (456.30)	1,808.29 (386.08)

According to the self-reports, there were no differences in the average energy intakes during the weekdays (Mann-Whitney U-test p=.79) and weekends (p=.52) among boys and girls. In both, weekdays and weekends, the energy expenditure among boys was higher than among girls (p=.02) (Table 2).

Correlations of BMI with Physical Fitness, Energy Intake and Energy Expenditure

Table 3. *Correlations of BMI with physical fitness variables and energy intake and expenditure during weekdays and weekends*

	r	p-value (2-tailed)
Sit-ups	-0.19	.117
Bent arm hang	-0.52	.000
600 m run	0.47	.000
20 m endurance shuttle run	-0.37	.001
Peak VO_2	-0.35	.003
Energy expenditure weekdays	-0.07	.567
Energy intake weekdays	-0.25	.031
Energy expenditure weekends	0.08	.506
Energy intake weekends	-0.32	.005

There were significantly negative correlations between BMI and all selected tests of physical fitness ($p < 0.01$) except the test sit-ups. Significantly negative correlations between BMI and energy intake during the weekdays ($p < 0.05$) and weekends ($p < 0.01$) are also observed, but there were no significant correlations between BMI and physical activity levels (energy expenditure) (Table 3).

Certain Eating Habits (Breakfast and Snacks after 8 p.m.)

All children reported eating breakfast; more than half of them regularly (52.8%) and the other occasionally. Regular breakfast was more common among girls than boys (56.8% vs. 48.6%) and during the weekends than during the weekdays (98.6% vs. 55.6%).

Only two children (2.8%) ate snacks after 8 p.m. regularly. For this reason, we combined children with regular and occasional eating in one group (41.7%); 58.3% reported that they had never eaten snacks so late in the evening, while more girls (51.4%) than boys (31.4%) ate snacks after 8 p.m.

The relationship between the frequency of the two observed meals, physical fitness and sex of the students was negligible.

Discussion

The mean BMI of the measured children was similar to that of the Slovenian population of the same age (Starc, Strel, & Kovač, 2010) with boys having a higher BMI than girls (Starc et al., 2010; Kovač, Jurak, & Leskošek, 2012).

In this sample, the girls had better results in some tests of physical fitness (sit-ups, bent arm hang and 600 m run) than the boys. In the Slovenian population of this age, the results were the opposite: boys of this age were more fit than girls (Starc et al., 2010). Generally, the results of girls included in this sample were better than the results of the population (Starc et al., 2010).

Boys had better results in the endurance test 20 m shuttle run and peak VO_2. We used the absolute results of peak VO_2 (we did not take into account the body weight of children). If we would calculate the relative peak VO_2, the girls' results probably would not differ compared with the boys' results. Girls have less body weight, so the relative expenditure of l O_2/min/kg should be higher.

The results show that boys and girls reported a lower intake for a third than reported in other studies (Kellow, 2010; Table 4), especially those children with an increased BMI. This could imply that overweight children do not report their intake accurately or that they believe that they eat less than they actually do.

Table 4. *Recommended energy intake for children (Kellow, 2010)*

Age	Energy intake kcal/day - boys	Energy intake kcal/day - girls
1–3	1,230	1,165
4–6	1,715	1,545
7–10	1,970	1,740
11–14	2,220	1,845
15–18	2,755	2,110

We can conclude that both boys and girls in our study underestimated their energy intake, which is probably due to inaccuracies in reporting at this age. The data in our study were collected through a survey questionnaire, which has shown adequate validity and reliability in other studies. However, it can be noted that the energy intake was higher during the weekends than during the weekdays for both sexes, especially among boys, and the differences in reporting energy intake according to sex are smaller than those found in the literature (Kellow, 2010).

Energy expenditure among Slovenian children was similar to the findings in other studies (Kellow, 2010). Furthermore, in Slovenia, girls are less physically active than boys (Strel et al., 2007). The average energy expenditure during weekdays and weekends was slightly higher for boys (around 300 kcal) than girls. Physical activity levels were higher during the weekdays than on weekends for boys and girls (more than 100 kcal), which is similar to that reported by some other authors (Rowlands, Pilgrim, & Eston, 2008; Sorič & Mišigoj-Duraković, 2010; van Sluijs et al., 2008). Rather large differences were found in physical activity among individuals, since the differences in energy expenditure was 612 kcal. Higher levels of physical activity and energy expenditure among boys were also found in other studies (Brettschneider & Naul, 2007; Strel et al., 2007). For the basal metabolism, an 11-year-old child with an average weight (40 kg) and height (150 cm) needs from 1,308 kcal (girls) up to 1,348 kcal (boys). The energy expenditure of our children was higher (for 460 to 895 kcal); which represents one or two hours of moderate physical activity. Therefore, we can conclude that their physical activity levels comply with the recommendations of experts who recommend at least between 60 and 90 minutes of physical activity daily.

There were no significant correlations between BMI and physical activity levels. In contrast, BMI was significantly associated with all selected tests of physical fitness, except the sit-ups test. Children with higher BMI achieved worse results in physical fitness tests, since being overweight is a limiting factor, both in strength and aerobic fitness (Andersen et al., 2007). The reason that the correlation between the sit-ups and BMI was not noticed is likely in fact that during sit-ups they only partially overcome the weight of their body (Jurimae & Jurimae, 2000). Livingstone (2000) also points out that BMI is not the most reliable indicator of voluminosity of the body, because it does not include data on the proportion of body fat. During adolescence, body composition can change, but the body weight often remains unchanged. A higher BMI can be the result of a higher proportion of either fat mass or muscle mass (Shepard, 2005). The results of other Slovenian studies have also shown that the results in sit-ups improved regardless of the age of children, especially among girls (Strel et al., 2007; Starc et al., 2010).

The relationship between the frequency of the two observed meals, physical fitness and gender was negligible. Although some other studies emphasise the importance of breakfast (Veltsista et al., 2010), our study did not confirm that regular breakfast and omitting late evening snacks are correlated with the physical fitness of children.

More thorough investigation of this problem should be conducted in future but there is a possibility that physically active children, who often practise sport in the evening, require higher energy inputs and also eat late.

Conclusion

Obesity is attributed to an energy imbalance, and is likely not ascribed to recent changes in genetics but rather a result of changes in the food and physical activity environments (Spiegelman & Flier, 2001). For children under the age of 12 years, the home environment has also been suggested as critical for providing access to healthy foods and opportunities for physical activity (Kumanyika, 2008; Kumanyika, Parker, & Sims, 2010). Our study shows that BMI has an important influence on physical fitness, since children with higher BMI achieved poorer results in most tests.

Children in our study, especially those with higher BMI, reported a one third lower intake than has been observed in other studies. Since the eating habits and energy intake were measured by questionnaires, we assume the results did not reflect the actual situation. The original questionnaire was developed in the USA; therefore, there were some difficulties with assessing the caloric value of some typical Slovenian dishes and determining the amount of food consumed. Furthermore, the tracking of food consumption proved difficult for 11-year-old children. The questionnaires provide subjective pictures of children's eating patterns, and show that children clearly underestimate their energy intake. We can conclude that the assessment of energy intake using a self-report questionnaire is problematic for this age group, especially among those with a higher BMI. In future research, more detailed guidance about tracking the food consumption should be provided to children or an interview approach should be used.

Despite the inaccurate reporting the physical activity levels were higher during the weekdays than on weekends, but the energy intakes were higher during the weekends. Although the relationship between the frequency of the two observed meals, physical fitness and gender of the students was negligible, further investigation of this problem should be conducted in the future.

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Marjeta Kovač
Faculty of Sport, University of Ljubljana
Gortanova 22, 1000 Ljubljana, Slovenia
marjeta.kovac@fsp.uni-lj.si

Janko Strel
Faculty of Sport, University of Ljubljana
Gortanova 22, 1000 Ljubljana, Slovenia
janko.strel@fsp.uni-lj.si

Gregor Jurak
Faculty of Sport, University of Ljubljana
Gortanova 22, 1000 Ljubljana, Slovenia
gregor.jurak@fsp.uni-lj.si

Bojan Leskošek
Faculty of Sport, University of Ljubljana
Gortanova 22, 1000 Ljubljana, Slovenia
bojan.leskosek@fsp.uni-lj.si

Saška Dremelj
Faculty of Sport, University of Ljubljana
Gortanova 22, 1000 Ljubljana, Slovenia
Saska.dremelj11@gmail.com

Petra Kovač
University Medical Centre Ljubljana,
Zaloška 2, 1525 Ljubljana, Slovenia
kovacpetra@yahoo.com

Marjeta Mišigoj-Duraković
Faculty of Kinesiology, University of Zagreb
Horvaćanski zavoj 15, 10 000 Zagreb, Croatia
marjeta.misigoj-durakovic@kif.hr

Maroje Sorić
Faculty of Kinesiology, University of Zagreb
Horvaćanski zavoj 15, 10 000 Zagreb, Croatia
masoric@kif.hr

Gregor Starc
Faculty of Sport, University of Ljubljana
Gortanova 22, 1000 Ljubljana, Slovenia
gregor.starc@fsp.uni-lj.si

Fizička aktivnost, razine fizičke kondicije, dnevni unos energije i neke prehrambene navike 11-godišnjaka

Sažetak

Cilj istraživanja bio je analizirati odnos između unosa energije, potrošnje energije, fizičke aktivnosti i razine fizičke spremnosti, indeksa tjelesne mase te nekih prehrambenih navika (doručak i lagani obroci poslije 20.00 sati) kod 11-godišnjaka. Načinjen je klaster uzorak od sedamdeset i dvoje djece (35 dječaka i 37 djevojčica) u dobi od 11.8 (±0.3) godina. Mjerenje se održavalo dva radna dana i dva dana vikenda. Potrošnja energije i fizička aktivnost procijenjeni su višesenzornim tjelesnim monitorima (SenseWear Armband; BodyMedia Inc., Pittsburgh, PA, USA). Unos energije i učestalost doručka i laganih obroka poslije 20.00 sati procijenjeni su prema odgovorima sudionika u upitniku (My Pyramid Tracker Tutorial; USDA, Center for Nutrition Policy and Promotion, USA). Razine fizičke spremnosti procjenjivane su prema rezultatima testova: podizanje trupa, izdržaj u visu, trčanje 600 m i izdržljivosti 20 m shuttle-run (korišten je Eurofit protokol), kao i prema rezultatima vršnog VO_2 mjerenog prijenosnim sprirometrom Cosmed K4b2. Pearsonov korelacijski koeficijent korišten je kako bi se testirale korelacije među promatranim varijablama, a multivarijantna analiza varijance korištena je kako bi se testirale razlike među grupama prema njihovoj fizičkoj spremnosti, frekvenciji spomenutih obroka i spolu. Rezultati pokazuju da dječaci i djevojčice, posebno oni s povećanim indeksom tjelesne mase (ITM), imaju za trećinu manji unos nego što je to bilo u prijašnjim analizama. Djevojčice su manje fizički aktivne od dječaka. U obje grupe razine fizičke aktivnosti bile su veće tijekom tjedna nego u vrijeme vikenda, ali unos energije bio je veći u vrijeme vikenda. Statistički značajne korelacije između ITM i razina fizičke aktivnosti nisu uspostavljene. ITM je značajno povezan sa svim spomenutim testovima fizičke spremnosti, osim u slučaju trbušnjaka. Odnos između učestalosti spomenutih obroka, fizičke spremnosti i spola učenika nije bio statistički značajan.

Možemo zaključiti da je procjena unosa energije i samoprocjene učenika u upitniku problematična za navedenu dobnu skupinu, posebno kod djece s povećanim ITM. Mjerenja fizičke aktivnosti ukazala su na to da bi učenici trebali biti aktivniji tijekom vikenda.

Ključne riječi: *doručak; ITM; lagani večernji obroci; potrošnja energije; radni dani; vikendi; životni stil djece.*