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ORIGINAL ARTICLE

Anthropometric outcomes associated with a primary school-based health promotion programme in the Italian city of Parma

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Abstract The City Council of Parma and allied partners launched a programme based on professionally guided physical exercise and nutritional education in all primary schools of the metropolitan area, with a total of 7,000 children involved, ranging from 6 to 10 years of age. One scientific end-point of the programme was the definition of the parameter(s) most associated with increased physical activity and potential modification of eating habits. To this purpose we studied in a cohort of 2,151 9-year-old children the associations among BMI, fat mass (FM), breakfast eating and the amount of physical activity, the most relevant variables that characterize lifestyle. There was a consistent significant inverse correlation between FM and physical activity and a significant correlation between FM and breakfast skipping. When sorted by BMI, an inverse significant correlation was found between FM and physical activity in boys, except in those underweight. In girls, a significant correlation was found in those of normal weight, but not in those overweight or obese. The number of sports practised was related to FM only in overweight and obese boys. Breakfast skipping was significantly correlated with FM only in underweight girls. Taken together, our data show that FM can be used to accurately evaluate physical activity and eating habits in children, and suggest that, in preventive health programmes, the fundamental parameter to pay attention to is the amount rather than the type of physical activity.

Key words BMI · Fat mass · Physical exercise · Lifestyle · Paediatrics

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Introduction

The frequency of overweight and obesity has rapidly increased worldwide in recent years [1–4]. Indeed, it is now well established that several chronic diseases typical of western countries, such as diabetes, cardiovascular diseases and hypertension – all featuring metabolic syndrome – are frequently associated with obesity both in adults and in children [5]. Although recent literature overwhelmingly tells us that causes of overweight and obesity are complex and that genetic factors may influence the susceptibility of an individual to gain weight [6], these conditions are in general accompanied and sustained by a positive energy balance. No doubt exists about the causal link between the decline in habitual physical activity that characterizes western lifestyle and health [7], and that the obesity epidemic is essentially driven by lifestyle rather than by biological factors [8]. A sedentary lifestyle is the common aetiopathogenetic basis of paramorphism of the different organs and systems, which characterizes the hypokinetic syndrome. Since there is a strong behavioural component in both sides of energy balance (i.e. dietary intake and physical activity), and overweight and obesity in adulthood are predicted by overweight in childhood, it is now generally accepted that prevention should start early in life and that school represents a privileged institution for promoting a correct lifestyle beginning from a younger age. As a consequence, several school-based interventions promoting both physical activity and healthy eating have been introduced throughout Europe [9].

It must be said, however, that to date most of these interventions have not generated a robust and stable reduction in the prevalence of overweight and obesity particularly in the medium to long term [10], despite the behavioural changes induced. On the one hand this might be due to the lack of a careful methodological and conceptual framework in the design of projects before their large-scale implementation [11], and on the other it must be noted that although a relationship between the activity levels of children, their aerobic fitness and their level of fatness has been demonstrated [12], it is still unclear which aspects of physical activity are really relevant in regulating body weight [13–15]. Interestingly, Steele et al. [16] recently dissected the different quantitative components of physical activity in relation to adiposity indexes in a cohort of UK children aged 9–10 years. Their results show that only time spent in vigorous physical activity is strongly associated with adiposity, while light intensity activity and sedentary time are not.

The City Council of Parma – Department for Sport and Physical Exercise, in collaboration with the Department for School and Education, the Curriculum of Sport Sciences and Physical Exercise of the Faculty of Medicine, University of Parma, the local Olympic Committee, and the Barilla Group S.p.A., launched a programme based on professionally guided physical exercise in most primary schools of the metropolitan area, with a total of 7,000 children involved, ranging from 6 to 10 years of age. During the curricular hours of physical education, the children of each classroom participating in the project were trained by a professional trainer.

One scientific end-point of the programme was the definition of the parameter(s) most associated with increased physical activity and potential modification of eating habits. To this purpose the aim of this study was to examine the association among BMI, fat mass (FM), breakfast eating and the amount of physical activity in the 9-year-old subcohort of this group (2,151 children; 1,049 boys, 1,102 girls). Specifically, we studied the correlations between FM, BMI and the following variables: amount of physical activity (expressed as minutes of physical activity per week), number of sports practised (single or multiple), and breakfast skipping during work days.

Materials and methods

Subjects

Out of a total population of 7,000 individuals, 2,151 Caucasian children were included in this study (1,049 boys, 1,102 girls) aged 9.6 ± 0.6 years from 25 primary schools located in the metropolitan area of Parma, Italy, as part of the GIOCAMPUS project. Written consent was obtained from the children's parents (or legal guardians) through the school administration. Each school was attended by students from urban and rural areas of the region. Inclusion criteria for the subjects were absence of major pathologies.

Anthropometric measurements

Anthropometric measurements focused on BMI and FM. BMI was calculated as body weight in kilograms divided by height in metres squared. All measurements were made by two independent qualified technicians. Body weight and height (without shoes) were measured wearing minimal clothing to the nearest 0.1 kg and 0.1 cm, respectively. Measurements were obtained in the morning, with no instructions about voiding. When the values obtained from the two independently repeated measurements differed by >2%, a third measurement was done and the average calculated. The equipment used for measuring height (Harpenden stadiometer) and weight (InBody 230; Biospace, Seoul, South Korea) were the same for every measurement. Table 1 summarizes the anthropometric data of the studied population. BMI was then used as an entry parameter to divide the subjects into four classes (underweight, healthy weight, overweight and obese). As BMI for children is age- and gender-specific, a gender-specific BMI-for-age (9 years) was used on a percentile basis [17, 18]. Therefore, the classification was:

Table 1 Demographic and anthropometric data of the studied population

	Age (years)	Height (cm)	Weight (kg)	BMI (kg · m^{-2})	Fat mass (%)
Girls	9.6 ± 0.6	140.9 ± 7.9	36.4 ± 8.7	18.2 ± 3.2	14.3 ± 2.9
Boys	9.6 ± 0.6	140.9 ± 7.1	37.1 ± 8.4	18.6 ± 3.2	14.9 ± 2.7
All	9.6 ± 0.6	140.9 ± 7.5	36.7 ± 8.5	18.4 ± 3.2	14.6 ± 2.8

1. Underweight (5th percentile) with a BMI <14 kg · m^{-2} in boys and <13.8 kg · m^{-2} in girls.
2. Healthy weight (5th to 85th percentile) with a BMI in the range 14.1–18.5 kg · m^{-2} in boys and 13.9–18.9 kg · m^{-2} in girls.
3. Overweight (85th to 95th percentile) with a BMI in the range 18.6–20.9 kg · m^{-2} in boys and 9.0–21.7 kg · m^{-2} in girls.
4. Obese (>95th percentile) with a BMI >21 kg · m^{-2} in boys and >21.8 kg · m^{-2} in girls.

FM was calculated from the bioimpedance value [19]. Total FM and total lean mass were measured with a bioelectrical impedance analyser (BIA) (InBody 230; Biospace, Seoul, South Korea) using multifrequency segmental bioelectrical methods. In accordance with most bioimpedance validation protocols [20–23], participants (and their parents/supervisors) were instructed to fast for at least 3 h and not to drink water or exercise for at least 2 h before BIA measurement. Under the supervision of a trained instructor, during the test children stood on a footplate with two electrodes per foot, holding a handgrip with two electrodes per hand.

Physical activity and breakfast eating

Data on the number of sports practised (one or more), physical activity level (as minutes of physical activity per week), and breakfast eating (yes/no) were obtained by directly interviewing the children's parents or guardians. The number of sports practised was categorized as follows: 1 only one sport practised under the supervision of a trainer either in school or out of school; 2 multiple (two or more) sports practised either in school or out of school under the supervision of a trainer (termed multisportsmanship). For the purpose of this survey breakfast was defined as any intake of food or beverage between 6 and 8 a.m. Parents were asked whether their children consumed breakfast on weekdays and at the weekend. Eating breakfast once per week was considered as not having breakfast on weekdays (i.e. having breakfast only at the weekend was considered as not having breakfast). This reasonable cut-off has been used in a previous study [24].

Statistics

The analysis was carried out both for the total number of children and for boys and girls separately. Continuous variables are expressed as means and standard deviations, and categorical variables are expressed as absolute and relative frequencies. Pearson's correlation coefficient was used to measure associations between the continuous variables, while contingency tables together with the χ^2 test were used to evaluate associations among the categorical variables. All reported probability values (*P* values) were based on two-tailed tests and compared using a significance level of 5%. The SPSS statistical software package (SPSS, Chicago, IL) was used for all calculations.

Results

All (2,151) collected interviews were considered in the study. Appropriate data included 1,049 boys and 1,102 girls aged 9.6 ± 0.6 years. The mean BMI was 18.6 ± 3.2 kg · m^{-2} in boys, and 18.2 ± 3.2 kg · m^{-2} in girls. Table 2 shows the frequency of both girls and boys in each

Table 2 Distribution of the studied population in relation to BMI class

BMI class	BMI (kg · m^{-2})	Girls (*n* = 1,102)		Boys (*n* = 1,049)		All (*n* = 2,151)	
		%	*n*	%	*n*	%	*n*
Underweight	≤13.8	3.1	34	1.8	19	2.46	53
Healthy weight	13.9–18.9	63.8*	703	55.2*	579	59.6	1,282
Overweight	19–21.7	19.4	214	22.5	236	20.92	450
Obese	≥21.8	13.7**	151	20.5**	215	17.02	366

**p* <0.05, ***p* <0.001, χ^2 analysis

Table 3 Correlation between percent FM and physical activity, multisportsmanship and breakfast consumption in boys and girls

n		Physical activity (min · week^{-1}) Pearson correlation	*p* value	Multisportmanship χ^2	*p* value	Breakfast skipping χ^2	*p* value
Girls	1,102	0.102	0.001	6.737	ns	12.547	0.01
Boys	1,049	0.166	<0.001	28.484	<0.001	9.595	<0.05

ns not significant

Table 4 Correlation between percent FM in boys in the different BMI classes and physical activity, multisportsmanship and breakfast consumption

BMI (kg · m^{-2})	Proportion of subjects (%)	Physical activity (min · week^{-1}) *n*	Pearson correlation	*p* value	Multisportsmanship *n*	χ^2	*p* value	Breakfast skipping *n*	χ^2	*p* value
≤14	1.8	19	−0.290	ns	nd			nd		
14.1–18.5	55.2	577	−0.108	<0.01	579	3.619	ns	579	1.085	ns
18.6–20.9	22.5	236	−0.192	0.01	236	14.529	<0.05	236	4.393	ns
≥21	20.5	215	−0.279	<0.001	215	9.292	0.05	215	0.309	ns

ns not significant

Table 5 Correlation between percent FM in girls in the different BMI classes and physical activity, multisportsmanship and breakfast consumption

BMI (kg · m^{-2})	Proportion of subjects (%)	Physical activity (min · week^{-1}) *n*	Pearson correlation	*p* value	Multisportsmanship *n*	χ^2	*p* value	Breakfast skipping *n*	χ^2	*p* value
≤13.8	3.1	34	−0.081	ns	34	0.971	ns	34	11.672	<0.01
13.9–18.9	63.8	703	−0.108	<0.01	703	5.715	ns	703	1.693	ns
19.0–21.7	19.4	214	−0.01	ns	214	5.632	ns	214	1.639	ns
≥21.8	13.7	151	0.130	ns	151	4.702	ns	151	0.316	ns

ns not significant

BMI class. Among the boys, 1.80% were underweight (BMI <14.0 kg · m^{-2}), 55.22% were of normal weight (BMI 14.1–18.5 kg · m^{-2}), 22.50% were overweight (BMI 18.6–20.9 kg · m^{-2}) and 20.50% were obese (BMI >21.0 kg · m^{-2}). Among the girls, 3.1% were underweight (BMI <13.8 kg · m^{-2}), 63.80% were of normal weight (BMI 13.9–18.9 kg · m^{-2}), 19.40% were overweight (BMI 19.0–21.7 kg · m^{-2}) and 13.70% were obese (BMI >21.8 kg · m^{-2}). The frequency of girls with a healthy weight was significantly higher than that of boys. On the contrary, significantly more boys than girls were obese.

In both boys and girls there was a significant inverse correlation between percent FM and minutes of physical activity per week and a significant correlation between percent FM and breakfast skipping, and in boys there was a significant correlation between percent FM and the number of sports practised (Table 3).

Tables 4 and 5 show the correlations between the same parameters when the studied subjects were divided into the appropriate BMI classes. An inverse significant correlation was found between percent FM and minutes of physical activity per week-1 in boys of all BMI classes, with the exception of underweight boys. On the contrary, in girls a significant correlation was found only in those of normal weight, and not in those overweight or obese. The number of sports practised was related to percent FM only in overweight and obese boys. Finally, breakfast skipping was significantly correlated with percent FM only in underweight girls.

Discussion

The results of this study show that FM can be used to accurately evaluate physical activity and eating habits in children, and that the amount rather than the type of physical activity is correlated with the biological parameters relevant to the health status of children.

Children are nowadays generally in a state of activity and fitness deficit. Indeed, it has long been known that although children are physically active during the day, less than 2% of their time is spent in activities of high enough intensity to promote cardiovascular health, whereas 80% of their time is spent in low-intensity activities [2]. Research has shown that most children do not receive enough fitness-enhancing activity during play to develop an adequate level of fitness or motor skill [25, 26]. As childhood has become more sedentary, children have put on weight [24] such that there is a threefold increase in the rate of childhood obesity. On the contrary, children engaged in daily physical education show superior motor fitness, academic performance and attitude towards school as compared with their counterparts who do not participate in daily physical education [27]. We have previously shown that a specifically designed physical exercise programme improves children's motor ability, demonstrating that – as expected – the quality of physical exercise affects the development of conditional and coordinative abilities without altering BMI values, and thus not interfering with the balanced progression of body weight and height [28]. Although here we did not measure the intensity of physical activity, as others have done elegantly in similar studies [16], nevertheless it is worth noting that our results are in line with previous reports in showing that the percent FM was inversely correlated with the amount of physical activity both in boys and girls.

Although breakfast skipping was found to be related to FM in the whole cohort (2,151), when subjects were grouped according to BMI categories, there was no longer a significant correlation for any of the categories (with the exception of the small category of underweight girls), in line with previously published data [29]. The number of sports practised was related to a lower FM only in overweight and obese boys, probably because of the significantly lower frequency of boys of healthy weight and the higher frequency of obese boys in our subject cohort as compared to girls (Table 3). Of note, classifying our subject cohort by BMI percentiles showed that FM was not associated with the amount of physical activity in the underweight subjects, probably because of the limited number of subjects in this class (19 boys and 34 girls) and probably the nonlinear correlation at lower values of FM. At variance with boys, FM was not related to the amount of physical activity in the overweight and obese girls, probably because in girls aged 9–10 years the combination of eating habits and prepuberty drives fat accumulation irrespective of the amount of physical activity. The hormonal pattern and timing of development in boys probably makes the FM at 9–10 years of age more sensitive to physical activity [30].

However, percent FM definitely appears to be a suitable parameter for the accurate evaluation of physical activity and eating habits in children, in line with the mounting evidence that BMI cut-offs should be carefully reconsidered in terms of predictive value [31].

Inactivity is certainly only one of the factors linked to obesity, but it is perhaps the easiest to modify. Body fatness and low physical fitness in children and adolescents are related to cardiovascular risk factors [32]. Although multisportsmanship has been demonstrated to be beneficial for the development of conditional and coordinative abilities in children, our data taken together show that when preventive health programmes are planned to promote physical activity in youngsters to avoid or minimize future risk factors, the fundamental parameter to pay attention to is the amount rather than the type of physical activity, which can be usefully left to the leisure preference of the child.

Perspectives

Health programmes including physical activity in primary school children are being progressively developed and implemented in the western world in proportion to the availability of scientific data able to generate best objective measurements of affordable anthropometric indicators and predictors of health status. In perspective, the multitude of anthropometric parameters available should be carefully selected for their real impact as biomarkers for lifestyle prescriptions for all ages, but particularly in children where the predictive component has a major relevance. Few but significant anthropometric parameters might then possibly be associated with individual wide genome analysis from the perspective of a personalized medicine that starts from lifestyle.

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Conflicts of interest None.

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