Relationship between body mass index and gross motor skill in four to six year-old children

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ABSTRACT

This study had to aim to verify the relationship between performance in gross motor skill tasks and body mass index (BMI) in four to six year-old boys and girls. 27 children were analyzed, 16 boys and 11 girls, mean age of 5.64 ± 0.67 years. The children were submitted to the *Test of Gross Motor Development-Second Edition* (TGMD-2), proposed by Ulrich (2000) and to the *Körperkoordinations-test für Kinder* (KTK), proposed by Kiphard and Schilling (1974). The punctuation obtained in the two tests was reduced to a scale common to both. The correlation between this scale and the BMI of the children was verified through the Spearman correlation test, with $P < 0.05$. No significant interaction was observed among variables when boys and girls were analyzed or when the analysis was conducted with gender distinction. Moreover, no interaction between the BMI and tasks which required higher demand of physical capacities was observed, which should be verified in further studies. It was possible to conclude from our results, that the performance of four to six year-old children in tasks which involved gross motor skill did not relate with BMI.

Keywords: Motor development. Motor assessment. Body mass index.

INTRODUCTION

Gross motor skill is classically defined by Clark[1] as the skill which involves in its manifestation the mobilization of large muscular groups which produce chest, arms and legs strength. This kind of skill is closely connected with several actions used on daily life, such as running, jumping, trotting, kicking, among others[1-2]. Its acquisition directly enables the development of more specialized skills, especially sports activities and/or systematized physical exercise programs[3]. Deficits in the gross motor skill reflect in low proficiency in more refined motor tasks which require the combination of these essential movements in the trial to acquire more elaborated skills. Moreover, such deficiency may also influence the affection-social behaviors of children, having a negative impact over self-esteem as well as motivation for physical activity practice[2].

Gross motor skill, similarly to motor development, is age-related, although it has been considered independent from it[4]. Such fact implies in assuming that quantitative and qualitative changes in movement occur as a consequence to several factors, especially the close interaction between restrictions imposed by the body, the environment and the task[5]. Thus, the development of gross motor skill is concerned with age, presenting optimum values at around seven years of age[4]. However, it basically depends on the amount of motor experience as well as practice faced in childhood[6].

Over the last years, a considerable increase of typically sedentary behavior which occurs with adults, children and adolescents as well has been observed. Such behavior seems to be closely connected with the lack of motor experiences and the engagement in physical exercise programs, which may partly imply in the levels of motor coordination, as well as in the increase of overweight and obesity, particularly in the first years of life[7-8]. It is worth mentioning that many investigations which try to verify this phenomenon in these age groups have used the body mass index (BMI) as criterion for classification of overweight and obesity[9-11].

Concerning the increase in excessive body weight cases among children and young adults, many studies have been developed with the purpose to investigate the interference of the overweight and obesity indices over physiopathological aspects concerned with the manifestation of chronic-degenerative diseases in adulthood[12-13]. On the other hand, little is known about the effect of this phenomenon over aspects of motor development in children, especially concerning gross motor skill.

Within this context, Pinho and Petroski[14], point out that overweighed or obese children present lack of physical activity as remarkable characteristic of their usual behavior and that this lack, besides being linked with cardiorespiratory problems and chronic conditions, may also reflect in an insufficient motor experience which reflects over the development of gross motor skills. Nevertheless, such prerogative cannot be securely adopted with any further studies which can test it.

In the common sense, there seems to be a trend to underestimate the motor skills of obese or overweighed children. Notably, it is reflected in physical education classes and professional intervention programs in which the teacher many times considers these children unable to reach success in motor tasks. Thus, such behavior leads to less motor experience from the children side, harming the development process of gross motor skill.

Therefore, considering the high prevalence of overweight and obesity in children and the relevance of the development of gross motor skill for the general motor development of these individuals, the aim of the present study was to verify the relationship between gross motor skill with body mass index in 4-6 year-old boys and girls.

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METHODOLOGY

Subjects

27 children (16 boys – 5.7 ± 0.7 years and 11 girls – 5.6 ± 0.7 years), mean age of 5.6 ± 0.7 years participated in the study. They were all students of a nursery school from Londrina-PR who participated once a week in regular physical education classes with duration of one hour. The authorization for the participation in the study was obtained with the nursery school principal. Moreover, all individuals responsible for the students after being informed on the purpose of the investigation as well as the procedures to be adopted signed a free a clarified consent form.

Anthropometry

Weight of the subjects was obtained on a Wiley digital scale, with 0.05 kg precision and height was determined in wooden stadiometers with 0.1 cm precision, according to procedures described by Gordon *et al.*[15]. The body mass index (BMI) was then determined, making use of these data.

Motor tests

Concerning gross motor skill, there are difficulties in measurement, once tests disseminated in the literature are scarce[16], especially concerning parameters of Brazilian children. Within this context, two evaluation instruments were selected in this study in order to evaluate the motor development of the children: the *Test of Gross Motor Development – Second Edition* (TGMD-2), proposed by Ulrich[2] and the *Körperkoordinations-test für Kinder* (KTK), proposed by Kiphard and Schilling[17].

The TGMD-2 consists of an analysis of six locomotion tasks (running, jumping, jumping on one leg, horizontal jumping, jumping one obstacle, sliding and galloping) as well as six object control tasks (hitting back, gripping, bouncing, throwing, rolling and kicking). The performance of each child in the tasks of this test was recorded on VHS tape for later analysis. Each task had a certain number of performance criteria concerning the quantitative analysis of the movement as follows: the child received one (1) point if fulfilled the criterion and no points if did not fulfill it. Later, the sum of the points was obtained in each sub-test, named in the test as raw scores. The analysis of the performance criteria was done by two evaluators trained and experienced in evaluation of tests in two similar situations. The intra and inter-evaluator correlation was calculated according to the model proposed by Thomas and Nelson[18] and surpassed 0.90 for all tests.

The KTK consists of the performance of four motor tasks: balance during backwards gait, jumps on one leg, lateral jumps and transference on platforms. This test involves all aspects characteristic of a motor coordination state, which has as components balance, rhythm, laterality, velocity and agility[19]. The performance analysis of the child occurs through quantitative measures of movement, being the number of steps during backwards gait, jumps on one leg at different heights, lateral jumps and performed transpositions registered. In the KTK, only one evaluator was chosen to point out and register the punctuation of the children in each task. Note that the decision to use two evaluators in the TGMD-2 test was due to the fact that this test performs a qualitative analysis of the movement.

The TGMD-2 and the KTK are tests which have not been used so far in validation studies for Brazilian children; consequently, its classification becomes useless in the evaluation of motor behavior. Therefore, the criteria/norms adopted in the tests were not considered, which were built from the classification of the percentile curve generated by the analysis of the performance of the children who are in the normative sample. Thus, the classification of each child was generated by the order of punctuation in each test, that is, from the raw scores of the TGMD-2 and the punctuation of the KTK. The subjects were classified concerning their position in the group, in first place, second and so forth. Had a tie occurred in a given position, the arithmetic mean of the two positions which the numbers occupied was calculated, establishing to the following classified subject the following position. The term 'classification order' or simply 'classification' will be adopted to refer to this procedure in this investigation.

Such classification was obtained concerning the two sub-tests of the TGMD-2 and the sum of them. In the KTK, the classification was obtained in each of the four tests which compose it as well as in their sum.

Statistical analysis

The data were initially treated from the descriptive procedures of mean and standard deviation. The normality test by *Shapiro Wilk* was used to verify the data distribution. The *t Student* test for independent samples was applied for comparison between boys and girls concerning anthropometric variables. The association between the BMI and the gross motor skill was analyzed through the *Spearman* correlation (r_s). The significance level established was of 5% ($P < 0.05$). The data were processed in the computer software *STATISTICA™*, 6.0 version.

RESULTS

Table 1 shows the mean values and the standard deviation of weight, height, and BMI of boys and girls analyzed in this study. The t test for independent samples did not identify significant differences between genders for weight, height and BMI. The children presented mean BMI of 16.9 ± 2.0 Kg/m^2, ranging from 14.5 to 21.3 Kg/m^2. According to the classification proposed by Cole *et al.*[20], five children were considered obese (18%) and four overweighed (15%), with a total of around 33% of the sample (obese + overweighed).

TABLE 1
Anthropometric characteristics of the studied subjects, mean values, standard deviation and t-test according to gender

	Boys	Girls	*t*	*P*
Age (years)	5.7 ± 0.7	5.6 ± 0.7	0.15	0.87
Weight (kg)	22.0 ± 4.2	22.0 ± 4.5	0.01	0.99
Height (cm)	113.3 ± 6.0	113.9 ± 5.0	0.02	0.78
BMI (kg/m^2)	16.8 ± 2.0	16.9 ± 2.0	–0.17	0.86

Initially, the *Spearman* correlation (r_s) was conducted in order to verify if there was a relationship between the children's classification in the two tests. Therefore, the classification order of the children was obtained concerning the sum of the raw scores in the TGMD-2. Moreover, all values obtained in the four tasks of the KTK were added. Consequently, no significant correlation was verified for the boys ($r_s = –0.48$) or the girls ($r_s = –0.01$), which shows that if a child had high scores in one of the tests, she does not necessarily will reach higher scores in the other test.

When the general performance in the motor tests were correlated with the BMI a low correlation both for the TGMD-2 ($r_s = –0.09$) and the KTK ($r_s = –0.04$) was verified. This analysis was conducted from the punctuation reached by all the children.

The same situation occurred when the correlation between the children's classification with the BMI in each one of the tasks which are in the TGMD-2 and the KTK was analyzed, since no significant correlation was observed, as is seen in table 2.

When the analyses were isolatedly conducted for each gender, once again no significant correlations were found for girls or boys (table 3).

TABLE 2
Spearman* correlation coefficients (r_s) between body mass index (BMI) and classification of each motor task in the *TGMD-2 and* KTK *tests

	r_s	*P*
TGMD-2		
Locomotion sub-test	0.17	0.93
Object control sub-test	–0.15	0.44
KTK		
Balance	–0.05	0.78
Jumps on one leg	–0.06	0.75
Lateral jumps	–0.23	0.25
Lateral transposition	–0.06	0.77

TABLE 3
***Spearman* correlation coefficients (r_s) between body mass index (BMI) and classification of boys and girls in each task of TGMD-2 and KTK**

	Boys		Girls	
	r_s	*P*	r_s	*P*
TGMD-2				
Locomotion sub-test	0.01	0.98	0.05	0.87
Object control sub-test	–0.20	0.45	–0.14	0.67
KTK				
Balance	–0.21	0.41	0.43	0.18
Jumps on one leg	–0.04	0.56	–0.02	0.96
Lateral jumps	–0.06	0.82	–0.42	0.20
Lateral transposition	0.02	0.93	–0.23	0.50

DISCUSSION

The role of education in the development of the gross motor skill of a child has been defended over the last years[21]. The role of the physical education teacher has also been involved. Actually, education seems to be essential for the motor development since difficulties in this continuous process of changes are usually linked with lack of motor experience[22] or lack of suitable instruction, as well as lack of opportunities for diverse practice[4,23] or even by motivational factors[4]. Therefore, it is essential that the physical education professional knows the development process which the students face in order to guarantee a safe intervention. In this investigation, we privileged the knowledge on the interaction between one of the indicators of overweight and obesity, the BMI, and the gross motor skill.

Initially, it is important highlighting that there was no equivalence concerning the children's performance in the TGMD-2 and in the KTK, which suggests that the children's responses were different in the two tests. Probably, these differences would be related to the kinds of tasks required in each of them, once quantitative measures of movement are predominant in the KTK, while qualitative measures are the foundation of the TGMD-2 analysis. One also sees that in the KTK a greater demand of physical capacities such as velocity, agility or muscular power is present. The origin of these differences and the lack of relationships between tests will not be widely discussed here since they are not relevant to the aim of this investigation. However, they can be understood as a complement, since motor characteristics which are not picked by a test may be picked by the other. Therefore, the relationship between BMI and one of the motor tests will not necessarily behave similarly for the other test, enabling the verification of the interaction between BMI and gross motor skill in different situations, in a wider analysis.

In the analysis of the relationships between BMI and the standardized measurements of performance, no significant relationships were identified in the general analysis of the children. That is to say that although the tests have accessed different analyses of movement (quantitative and qualitative) and the responses to these analyses are different, by increasing the variability of results and consequently the chance to exist any relationship among variables, there was not proportionality between performance in the tests and the BMI. Nevertheless, since differences in performance between boys and girls have been suggested[24-25], the correlation between BMI and the classifications of the tests concerning gender distinctions was also checked. There were not any significant relationships among the variables, though.

According to Eckert[26], the differences in performance of motor skills are attributed, among other factors, to different physical structures presented during life. Within this context, some investigations have recently tried to verify the influence of these structural characteristics in the motor aspects. Nunes *et al.*[27] investigated the influence of weight, height and body proportions in the manipulative and locomotor behavior of 6 and 7-year old children and concluded that these growth variables do not significantly influence the execution of basic motor skills for these children.

These results corroborate what was found by Machado *et al.*[24], when verified the relationship between body composition and performance of fundamental motor standards in 5-8-year old children, being their motor behavior accessed through an adapted TGMD-2 test. Significant relationships were not found between performance in the test and weight, fat mass and lean mass. These investigations reinforce the independence of performance in a task of gross motor skill concerning anthropometric and body composition indicators. Within this context, the present study also defends the autonomy of this aspect of motor development concerning one of the structural aspects in children: the BMI.

One may infer then that obese or overweighed children have the same potential of normal children for developing gross motor skill and that they are capable to perform movements with the same quality. The differences in performance in children therefore, must be probably more related with physiological responses than with the organization of the movement and motor development, a topic which should be verified in further studies. Thus, possible motor deficits in obese children should be carefully analyzed, especially through the observation of the influence of instruction and motor stimulation.

It is important to highlight that the fact that the KTK test, as previously mentioned, has greater demand of components related to physical capacities, it was expected that it presented higher correlation with the classification in its component tests. Surprisingly, the value of the correlations remained low for all conducted analyses. Further investigations which bring as independent variables physical and motor capacities are needed in order to better understand this fact.

As a restriction to this investigation, we especially highlight the selected sample as well as the motor tests. There were a small number of individuals classified as overweight or obese (33%). Therefore, new studies which may increase the sample, contemplating a wider number of obese or overweighed children are needed. Concerning the motor tests, the biggest issue has to do with the interpretation of the raw values reached, since there are not criteria/norms for Brazilian children. It is difficult to speculate about a satisfactory level or not of development in the gross motor skills; that is, the level of development of these skills is unknown, since every child may be at the same level. Thus, we should search for new studies which validate motor tests for gross motor skills.

Finally, it is worth mentioning that although the BMI is currently considered a good indicator for overweight and obesity diagnosis, since it presents low operational cost, is not invasive, enables comparisons with reference tables, has wide application in the educational environment and is of easy access to the physical education teacher. Nonetheless, the results should be carefully seen once the BMI may present a relatively limited discriminatory potential for the identification of obesity cases[28-29]. Therefore, it is suggested in future studies that besides the BMI, skinfolds thickness

measurements (tricipital and subscapular) are added in order to obtain more accurate data on the amount of body fat.

CONCLUSIONS

We may conclude that there was not correlation between the BMI and the classification of boys and girls in the KTK and TGMD-2 tests, showing an equal potential of motor development for all children, not being restricted by body adiposity. It is important to mention that the outcomes found in this investigation as well as the ones already mentioned by the literature do not defend or base the stereotype of obese or overweighed children as not skilled. On the contrary, they reinforce the idea that satisfactory execution of actions which involve Gross motor skill, due to the involvement of qualitative aspects of movement, is not linked with anthropometric or body composition characteristics.

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