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Correlations between anthropometric characteristics, heart rate and the results of the 8-second skipping with hand clapping (SHC) test in preschool children

ROBERT PODSTAWSKI[1], STANISŁAW KONOPKA[2], STEFAN MAŃKOWSKI[2], DARIUSZ CHOSZCZ[2], KRZYSZTOF BORYSŁAWSKI[3]

Abstract

Introduction. **Anthropometric measurements and the BMI are taken into account in the process of developing physical fitness tests for children.** Aim of Study. **The aim of this study was to describe the relationships between the anthropometric characteristics (body mass, body height, length of lower and upper limbs), BMI and speed abilities of preschool boys and girls performing the 8-second skipping with hand clapping (8-s SHC) test. The increase in HR during the test was also determined.** Material and Methods. **The test involved 60 girls and 57 boys aged 68.2 ± 11.33 months (min. – 56, max – 89). Their body mass, body height, length of lower and upper limbs and BMI were determined, and their speed abilities were evaluated with a 8-s SHC test. The participants' HR was measured before and after the test, and the exercise-induced increase in HR was calculated. The basic statistics were determined for all evaluated parameters and the coefficients of correlation between anthropometric features, HR, and the number of claps during the test were calculated.** Results. **Among the analyzed parameters, only body mass and BMI were significantly higher in boys than in girls. Mean HR increased during the 8-s SHC test in both girls and boys (to 149.40 and 152.9 bpm, respectively). The number of claps during the 8-s SK test increased significantly with an increase in the values of anthropometric measurements. Significant correlations between the analyzed parameters were not determined only for BMI and heart rate after the 8-s SK test.** Conclusions. **Anthropometric characteristics such as body mass, body height, length of lower and upper limbs significantly influenced the speed abilities of kindergarteners performing the 8-s SK test, whereas BMI was not significantly correlated with the results of the test.**

KEYWORDS: anthropometric characteristics, BMI, motor test, speed abilities, skipping with hand clapping for 8-s, changes in HR.

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Corresponding author: podstawskirobert@gmail.com

[1] *University of Warmia and Mazury in Olsztyn, Department of Physical Education and Sport, Olsztyn, Poland*
[2] *University of Warmia and Mazury in Olsztyn, Department of Heavy Duty Machines and Research Methodology, Olsztyn, Poland*
[3] *Wrocław University of Environmental and Life Sciences, Department of Anthropology, Wrocław, Poland*

What is already known on this topic?
The influence of anthropometric characteristics on children's motor performance has been demonstrated by many authors who found significant correlations between anthropometric traits and motor abilities and motor skills of kindergarteners. The relationships between anthropometric characteristics and motor abilities are also evaluated and taken into account in the process of designing motor tests, but they were not analyzed with the use of the 8-s skipping with hand clapping (SHC) test performed by kindergarteners.

Introduction

The presence of relationships between anthropometric traits and motor abilities was demonstrated by many studies of pre-school children [1, 2] and early school-age children [3, 4, 5]. These studies revealed that children's anthropometric parameters were significantly correlated with their motor abilities. An anthropometric feature that significantly limits endurance in children is body mass [6, 7], which is significantly positively correlated with strength [8, 9]. The body mass index (BMI) is a derivative of body mass, and excessive BMI values have a highly negative impact on exercise capacity, endurance, and even flexibility [10]. It should be noted, however, that the analyzed relationships are not always obvious in children [2, 11] and can be manifested differently in girls and boys [7, 12]. Sexual dimorphism is weakly accentuated in developing pre-school children, which is also visible in the physical fitness levels of boys and girls [2, 12]. Physical fitness is higher in children that are more physically developed [13].

The relationship between BMI and physical fitness in children is very important due to the dramatic increase in the number of overweight and obese children around the world [14]. Excessive body weight contributes to a host of lifestyle diseases in adulthood and significantly compromises the quality of life [15, 16]. Overweight and obese children are less active and, consequently, less physically fit [17, 18, 19] and more likely to pursue a sedentary lifestyle in adulthood [20, 21].

Anthropometric measurements and their derivatives, such as BMI and Rohrer's index, are also taken into account in the process of developing physical fitness tests for children and adolescents based on weight classes [22]. Before a fitness test is approved as a motor skill test, it should conform to a number of adequacy criteria, including relevance, reliability and objectivity, and it should be provided with a set of reference standards [23, 24]. Financial aspects and the time required to perform the test are also important considerations [25]. For instance, extreme length of upper and lower limbs significantly influences flexibility in the standing forward bend and the seated forward bend, which undermines the relevance and reliability of a fitness test for flexibility assessment [26, 27, 28]. For this reason, the relationships between anthropometric measures and the results of motor tests should be carefully analyzed before a given tests is regarded as consistent with the above criteria.

The aim of this study was to describe the correlations between the anthropometric characteristics (body mass, body height, length of lower and upper limbs), BMI and speed abilities of pre-school girls and boys in the 8-second skipping with hand clapping (8-s SHC) test. The increase in heart rate during the above test was also determined.

Materials and Methods

Participants

The study involved 117 pre-school children, including 60 girls and 57 boys, attending the "Leluki" private kindergarten in Olsztyn, Poland. All participants were permanent residents of Olsztyn and participated in physical education classes with an identical curriculum (with regard to the duration and type of physical exercise). Since differences in the physical activity levels of children participating in extracurricular sports could significantly distort the examined relationships, children performing additional sports activities as well as those excused from PE classes for medical reasons were excluded from the study.

Procedures

The study was performed following the provisions of the Declaration of Helsinki and upon the prior consent of the Bioethics Committee of the University of Warmia and Mazury in Olsztyn (UWM). The study was conducted upon the written consent of the kindergarten principal.

Measurements

A meeting was held with parents to collect additional information about the children's physical activity levels or limitations resulting from a medically certified illness. Anthropometric measurements were performed according to the methods proposed by Martin (body mass, body height, length of lower limbs – LL, length of upper limbs – UL). Body height was measured to the nearest 1 mm, and body mass – to the nearest 0.1 kg, with the use of the WB-150 electronic medical weighing scales with a stadiometer (ZPU Tryb-Wag, Poland). The Body Mass Index (BMI = body mass [kg] / body height [m]^2), which is generally regarded as a relevant and reliable statistic for evaluating excessive body weight and obesity also in children, was determined to assess the participants' nutritional status (body fat) [29]. Heart rate (HR) was measured with the Polar RS 100 pulse rate meter with a chest strap. Speed abilities were evaluated during the 8-second skipping with hand clapping (SHC) test. The original 10-second version of the test was developed for the Zuchora Physical Fitness Index [30]. All participants performed the test three times, with 4-minute breaks in between the three trials. The best of the three results was recorded together with the corresponding HR.

Description of the test: The participant stands in neutral position. When given a cue to start, he/she runs in place for 8 seconds, lifting the knees up high (thighs are at least perpendicular to the floor) and clapping hands under the bent and lifted leg. The number of claps in the 8-second period is the result. The participant should not slouch, should stand up erect, and should clap his/her hands against one another, and not against the lifted leg [30].

Anthropometric measurements and the 8-s SHC test were performed in a kindergarten gym room in March 2015 with the assistance of early education teachers working with the evaluated children. The teachers were suitably trained during a meeting held before the study. The children were instructed how to perform the 8-s SHC test correctly, and they were able to practice during three meetings preceding the study. Each child participated in three meetings (one per week) during which he/she performed the 8-s SHC test three times. Before the actual test, children participated in an 8-minute warm-up which was identical in all groups and consisted of movement play, trotting, arm swings, hip swings, leg swings, balance exercises, short (around 6 m) runs, stretching, and corrective exercises [31].

Statistical analysis

The basic statistics were determined for all evaluated parameters and the coefficients of correlation between anthropometric features and HR vs. the 8-s SHC test results, were calculated separately for girls and boys. The calculations were performed using Statistica ver. 10 software, at the level of statistical significance of $\alpha = 0.05$.

Results

The results are presented in Tables 1 and 2. The statistical characteristics of the parameters measured in girls and boys are shown in Table 1, and the coefficients of correlation between the analyzed parameters are shown in Table 2.

Table 1. Statistical characteristics of the analyzed parameters in girls and boys

Parameter	$\bar{X}$	Median	Minimum	Maximum	SD	CV [%]
Girls (N = 60)						
Body height [cm]	115.97	115.75	100.00	136.50	8.70	7.50
Body mass [kg]	21.07	21.25	14.00	30.00	4.05	19.20
BMI [kg/m^2]	15.60	15.27	11.81	22.32	2.07	13.26
UL length [cm]	51.73	52.00	43.00	62.50	4.22	8.15
LL length [cm]	57.48	57.00	47.50	69.50	4.97	8.64
Number of claps [N]	14.56	14.50	6.00	24.00	4.04	27.73
HR before test [bpm]	82.80	84.00	72.00	96.00	6.97	8.42
HR after test [bpm]	149.40	150.00	126.00	174.00	11.03	7.38
Increase in HR [bpm]	66.61	66.00	48.00	96.00	11.24	16.87
Boys (N = 57)						
Body height [cm]	117.96	117.00	102.00	146.50	8.99	7.62
Body mass [kg]	23.05	23.00	14.00	44.00	5.58	24.22
BMI [kg/m^2]	16.37	16.45	11.36	21.98	2.26	13.74
UL length [cm]	52.16	52.00	45.00	68.00	5.28	10.13
LL length [cm]	57.41	57.00	48.00	74.00	6.41	11.17
Number of claps [N]	13.87	14.00	4.00	23.00	4.90	35.28
HR before test [bpm]	83.78	84.00	72.00	96.00	5.89	7.03
HR after test [bpm]	152.00	150.00	132.00	174.00	9.37	6.17
Increase in HR [bpm]	68.21	66.00	42.00	90.00	9.26	13.57

Notes: SD – standard deviation, CV – coefficient of variation, HR – heart rate

Table 2. Coefficients r of correlation between anthropometric features and the parameters measured during the 8-s SCH test

Anthropometric features	Parameters measured during test			
	Number of claps	HR before test	HR immediately after test	Increase in HR
Girls (N = 60)				
Body height [cm]	**0.4909**	**–0.5501**	–0.1173	0.2283
Body mass [kg]	**0.3654**	**–0.3014**	–0.0593	0.1274
BMI [kg/m²]	0.0031	0.1559	0.0400	–0.0515
UL length [cm]	**0.5352**	**–0.4937**	–0.0396	**0.2653**
LL length [cm]	**0.4812**	**–0.5594**	–0.1979	0.1758
Boys (N = 57)				
Body height [cm]	0.5243	–0.4252	**–0.2756**	–0.0087
Body mass [kg]	**0.4628**	**–0.3647**	–0.2406	–0.0116
BMI [kg/m²]	0.2471	–0.0969	–0.0911	–0.0305
UL length [cm]	**0.5714**	**–0.4122**	–0.2586	0.0004
LL length [cm]	**0.5499**	**–0.4389**	–0.2813	–0.0057

Notes: HR – heart rate, statistically significant values at $p \leq 0.05$ indicated in **bold**

A comparison of the mean values of anthropometric features revealed statistically significant differences between girls and boys only in body mass ($p = 0.0297$) and BMI ($p = 0.0497$). Boys were characterized by significantly higher average body mass and BMI values. The remaining anthropometric features, HR values, the increase in HR, and the number of claps did not differ significantly between genders (Table 1).

The evaluated anthropometric features, excluding BMI, were significantly correlated with HR before the test and the number of claps in both genders. HR immediately after the test was negatively correlated with body height in boys only, whereas the increase in HR was positively correlated with UL length in girls only. Anthropometric features were positively correlated with the number of claps and negatively correlated with HR before and after the test. The only exception was a statistically non-significant correlation between BMI and HR (Table 2).

Discussion

All of the evaluated anthropometric features were significantly positively correlated with the number of hand claps made within 8 seconds. Therefore, it can be assumed that more physically developed children will score better on the 8-s SHC test.

The absence of significant correlations between BMI and the number of claps within 8 seconds could be attributed to the fact that BMI values were within the norm in both girls and boys. A lack of relationships between BMI values and speed abilities was also observed in our previous study of early school-age children [9], and similar results were noted by De Toia et al. [2]. Okely et al. [32] and Southal et al. [33] reported an absence of correlations between BMI values and the results of stationary object control tasks (e.g. digging, throwing, catching and hitting) in children, but the BMI values were correlated with the children's performance in fitness tests that involved running and jumping. Overweight children are less active and characterized by less developed physical fitness [34, 35], but the mechanisms responsible for the relationships between excessive body weight / obesity and motor abilities have not yet been thoroughly investigated [36], and there is a scarcity of longitudinal studies comparing the fitness levels of obese and normal-weight children, in particular among preschoolers [37, 38]. The test used in this study is a standard anaerobic exercise which is highly representative of the type of physical activities undertaken by children on a daily basis [39], and the above could have influenced the results of the 8-s SHC test.

The increase in HR was significantly correlated with UL length in girls only, which could indicate that anthropometric features are generally not linked with heart rate after the 8-s SCH test. Resting HR decreases during childhood and reaches around 85 bpm at the age of 5 years [40]. This observation is consistent with the results of our study where mean HR was determined at 82.80 bpm in girls and at 83.78 bpm in boys. The increase in HR (by 66.61 bpm in girls and by 68.21 bpm in boys on average) as well as mean HR immediately after the test (150 bpm in both genders) and maximum HR (174 bpm in both genders) indicate that the evaluated exercise is a high-intensity activity. In short submaximal and maximal exercises, HR often exceeds 200 bpm in children under the age of 10 [40]. Such high heart rates indicate that a child's cardiovascular system can effectively adapt to intense exercise by rapidly attaining 50% of maximal oxygen uptake [41]. In this study no differences were noted between mean and maximum HR values after the 8-s SHC test, and similar observations were made by some physiologists [40]. In other studies, boys were characterized by higher HR values than girls in submaximal and maximal exercises [42, 43].

Practical implications and limitations

At present, the 8-s SCH test is used to test the speed at which a motor ability test can be performed, but it is also largely geared towards evaluating coordination abilities [44, 45]. Follow-up research is, therefore, needed to determine the reliability and relevance of the 8-s SCH test and, ultimately, to propose classification standards for different age groups. The 8-s SHC test is very easy to conduct even in difficult conditions. It was first used in a population study of first-year students of the University of Warmia and Mazury in Olsztyn, Poland [46]. In successive years, the authors relied on the 8-s SHC test to assess the motor skills of pre-school children, early school-age children, university students and early education teachers [45]. However, our study results should be compared with the findings of other authors for greater objectivity.

Conclusions

Anthropometric characteristics such as body mass, body height, length of lower and upper limbs significantly influenced the speed abilities of kindergarteners performing the 8-s SHC test, whereas BMI was not significantly correlated with the results of the test. The number of claps during the 8-s SHC test increased significantly with an increase in the values of anthropometric features. The evaluated anthropometric features were not significantly correlated with an increase in HR or HR measured immediately after the 8-s SHC test.

What this study adds?

In this study, the 8-s SHC test was analyzed in detail to determine its applicability for evaluating speed abilities in children. An evaluation of its potential application in population-based studies revealed that the test is very cheap and easy to perform in a group of kindergarteners, even in very difficult conditions. The results of our study confirmed the well-known fact that more physically developed children tended to score better results in motor tests. BMI scores were not significantly correlated with the results achieved by kindergarteners in the 8-s SHC test, therefore, future classification standards for pre-school children will not have to account for their nutritional status based on BMI norms.

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