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CORRELATION OF ANTHROPOMETRIC INDICATORS AND MUSCULOSKELETAL FITNESS IN ELEMENTARY SCHOOL AGE CHILDREN

Eka Roina Megawati [1], Lokot Donna Lubis [2], Nuraiza Meutia [1]

1. Departement of Physiology, Faculty of Medicine, Universitas Sumatera Utara
2. Departement of Histology, Faculty of Medicine, Universitas Sumatera Utara

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ABSTRACT

Handgrip strength and standing long jump are two of the health-related fitness indicators that measure musculoskeletal fitness. The more active children will perform better in the physical fitness assessment. However, the nutritional status also determines health conditions. The aim of this study was to determine the correlation between anthropometric indicators and musculoskeletal fitness among elementary school age children. This study included 50 children (23 boys and 27 girls), between the ages of 7-11 years, recruited from an elementary school in Medan, Indonesia. The nutritional data that were measured are weight, height, body mass index, waist circumference, waist to height ratio, fat percentage, biceps, triceps and subscapular skinfold thickness. The anthropometric indicators that are strongly determinant factors for handgrip strength are age, weight, BMI, fat percentage, biceps, and triceps skinfold thickness. Meanwhile, for the standing long jump the indicators are gender, BMI and subscapular skinfold.

1. Introduction

Physical fitness determines an individual's ability to carry out daily activities without fatigue. Health-related fitness is one of the physical fitness components that may improve health and prevent the occurrence of degenerative diseases. The indicators of health-related fitness are cardiorespiratory fitness (CRF), strength, muscular endurance, flexibility, body composition and stress management (1). Reduced physical fitness is related to health problems, such as cardiovascular diseases, musculoskeletal problems and cognitive disorders (2).
Nowadays, there is a tendency for children to lead more sedentary behaviors, do less activities and spend more time with their gadgets, resulting in decreased energy output that can increase the risk of obesity (3). Meanwhile, in Indonesia the prevalence of overweight children between the ages of 5-12 years is 18.8 percent, with 10.8 percent being overweight and 8.8 percent obese(4).
The nutritional status describes the individual's health conditions (5). The information of cardio metabolic disorders risk factors, such as insulin resistance in preschool children with obesity, can also be detected by calculating the body mass index (BMI) (6). Insulin resistance is the risk factor of type 2 diabetes mellitus and can be detected by assessing the muscular fitness in both children and adolescents(7).
Children who are physically more active are associated with a favorable body composition, better cardiorespiratory and muscular fitness (8). Children with an active daily lifestyle perform better in physical fitness tests. Children and adolescents who ride their bikes to school have higher CRF compared to walkers and passive commuters (8).
Body composition in children can be assessed using the anthropometric indicators. There are many anthropometric indicators in children including body mass index (BMI), waist circumference, the ratio of height and waist circumference, triceps, biceps and subscapular skinfold thickness and fat mass percentage. The handgrip strength (HGS) and standing long jump (SLJ) are part of musculoskeletal indicators and are commonly used to measure the index of muscular fitness.
The aim of this study was to determine the correlation of anthropometric indicators and musculoskeletal fitness among elementary school age children.

Corresponding author: Eka Roina Megawati, *eka3@usu.ac.id*
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2. Material and methods

This study included 50 children (23 boys and 27 girls), between the ages of 7-11 years, recruited from an elementary school in Medan, Indonesia. Parents were fully informed about the purpose and methods of the study and signed a written consent. The ethical approval was obtained from Health Research Ethical Committee, Faculty of Medicine, Universitas Sumatera Utara/H Adam Malik General Hospital prior to the study.

All measurements were conducted in the school setting by trained personnel and an identical study protocol was used. All measurements were collected the same day per for each subject. The data collection was conducted in 2018.

Weight and height were measured in light clothing and without shoes. The weight was measured to the nearest 0.1 kg with a digital scale (Omron). Height was measured to the nearest 0.1 cm, using wall mounted tapes, with the child standing upright against the wall. BMI was calculated as weight (kg) divided by the height squared (m^2).

Waist circumference (cm) was measured by using flexible tape in the horizontal plane in the midway between the lowest rib line and iliac crest. Waist to height ratio was calculated by dividing the waist circumference (cm) and height (cm). Fat percentage was measured using the Karada scan body composition monitor (Omron). Biceps, triceps and subscapular skinfold thickness were measured by using the skinfold caliper from the right side of the body (Digital body fat caliper).

The handgrip strength was measured using electronic handgrip dynamometer (Camry Electronic Hand Dynamometer EH 101) that was adjusted to children's hand size. The measurement was conducted with the subject in the standing position with shoulders closed and neutral rotation,with arms parallel but no contact to the body. The subject was asked to squeeze the holder with maximal strength for 3-5 seconds without any verbal motivation. The test was repeated twice in each hand and the average was considered as the grip strength (kg). Therefore, the handgrip strength was the combination of left and right hand without consideration which hand was dominant.

The standing long jump (cm) was measured with the participants standing behind a line with feet slightly apart. They were instructed to strongly push with a two-foot take-off and jump as far as possible, and land on both feet in the erect position without falling backwards. The distance from the take-off line to the nearest point of contact on the landing (back of the heels or any parts of the body) was measured. The tests were conducted twice, the closest distance was used for the analysis.

Data are reported as mean ± (SD). A t-test was performed to compare the means between gender if the variables were normally distributed according the Shapiro Wilk test, while the Mann Whitney was used if otherwise. The Pearson's bivariate correlation was used if the variables were normally distributed, otherwise the Spearman's bivariate correlation test was used.

3. Results

Subject characteristics

A total of 50 children (23 boys and 27 girls) were included in this study, 54% females and 46% males. The characteristics of the anthropometric indicators based on the gender are shown in Table 1.

The mean values are: age of 9.94 ± 10.00 years-old, weight of 35.50 ± 12.58 kg, height of 136 ± 8.83 cm, BMI of 18.76 ± 4.94 kg/m2, waist circumference of 71.14 ± 11.32 cm, waist to height ratio of 0.52 ± 0.06, fat percentage of 12.22 ± 10.34%, biceps skinfold of 9.80 ± 5.25 mm, triceps skinfold of 16.22 ± 6.90 mm, subscapular skinfold of 11.61 ± 5.49 mm, handgrip strength of 14.34 ± 4.20 kg and standing long jump of 118.56 ± 16.51.

The subject characteristics that are normally distributed are height, handgrip strength and standing long jump.

Boys had a significantly higher of weight, BMI, waist circumference, height and waist circumference ratio, and subscapular skinfold ($p < 0.05$).

The standing long jump that were significantly different between sexes, girls had a significantly higher score of standing long jump (p= 0.002).

Variables	Total (n = 50)	Girls Mean ± SD (n = 27)	Boys Mean ± SD (n = 23)	p value
Age (years)	9.94 ± 10.00	9.78 ± 0.89	10.13 ± 1.1	0.090
Weight (kg)	35.50 ± 12.58	32.37 ± 10.52	39.16 ± 13.98	0.046*
Height (cm)	136 ± 8.83	134.96 ± 9.34	137.57 ± 8.16	0.304
BMI (kg/m^2)	18.76 ± 4.94	17.43 ± 3.9	20.30 ± 5.6	0.037*
Waist circumference (cm)	71.14 ± 11.32	67.59 ± 9.69	75.30 ± 11.87	0.013*
Waist to height ratio	0.52 ± 0.06	0.50 ± 0.05	0.55 ± 0.07	0.025*
Fat percentage	12.22 ± 10.34	9.9 ± 10.01	14.83 ± 10.32	0.092
Biceps (mm)	9.80 ± 5.25	8.83 ± 4.90	10.93 ± 5.52	0.085
Triceps (mm)	16.22 ± 6.90	15.53 ± 6.39	17.02 ± 7.50	0.586
Subscapular (mm)	11.61 ± 5.49	10.21 ± 5.05	13.52 ± 5.63	0.048*
HGS (kg)	14.34 ± 4.20	13.48 ± 4.43	15.35 ± 3.75	0.119
SLJ (cm)	118.56 ± 16.51	126.17 ± 15.27	112.07 ± 14.89	0.002*

*p<0.05

Table 1. Subject characteristics

Bivariant analysis

Table 2 shows the anthropometric indicators that are correlated to handgrip strength and standing long jump.

The anthropometric indicatorsthat were significantly correlated with the handgrip strength are age, weight, height, BMI, waist circumference, waist to height ratio, fat percentage, biceps skinfold, triceps skinfold and subscapular skinfold ($p<0.05$).

On the other hand, the anthropometric indicators that are significantly correlated to the standing long jump are gender, weight, BMI, fat percentage, triceps and subscapular skinfold ($p<0.05$).

Anthropometric indicators	Handgrip strength		Standing long jump	
	r score	p value	r score	p value
Age	0.452	0.001	0.050	0.728
Gender*		0.060		0.002
Weight	0.679	0.001	-0.307	0.030
Height	0.647	0.001	-0.145	0.314
BMI	0.572	0.001	-0.321	0.023
Waist circumference	0.620	0.001	-0.242	0.090
Waist to height ratio	0.452	0.001	-0.218	0.128
Fat percentage	0.638	0.001	-0.333	0.018
Biceps skinfold	0.442	0.001	-0.228	0.111
Triceps skinfold	0.353	0.012	-0.356	0.011
Subscapular skinfold	0.481	0.001	-0.321	0.023

*Mann Whitney test

Table 2. Pearson correlation between the anthropometric indicators and musculoskeletal fitness

Multivariate analysis

Based on the results of the bivariate analysis, the anthropometric indicators that can be included in the linear regression multivariate test for the handgrip strength are age, weight, height, BMI, waist circumference, waist toheight ratio, fat percentage, biceps skinfold, triceps skinfold, and subscapular skinfold ($p<0.25$).

The anthropometric indicators that can be included in the linear regression multivariate test for the standing long jump are gender, BMI, fat percentage, triceps skinfold, and subscapular skinfold ($p<0.25$).

The result of linear regression multivariate analysis with backward method for handgrip strength = 10.724 + 0.636*age + 0.312*weight – 0.864*BMI + 0.315*fat percentage – 0.247*triceps skinfold + 0.262*biceps skinfold (R2 = 56.7%).

The result of linear regression multivariate analysis with backward method for standing long jump = Standing long jump = 136.039 + 18.990*gender – 0.968*BMI – 0.694*subscapular skinfold (R2= 37.7%)

Anthropometric indicators	**Handgrip strength B-coefficient ± SE**	**p value**
Age	0.636 ± 0.498	0.209
Weight	0.312 ± 0.121	0.013
BMI	-0.864 ± 0.359	0.021
Fat percentage	0.315 ± 0.103	0.004
Triceps skinfold	-0.247 ± 0.118	0.042
Biceps skinfold	0.262 ± 0.145	0.079

Table 3. Multivariate analysis of the handgrip strength

Anthropometric indicators	Standing long jump B-coefficient ± SE	p value
Gender	18.990 ± 3.872	0.001
BMI	968 ± 0.773	0.216
Subscapular skinfold	-0.694 ± 0.692	0.321

Table 4. Multivariate analysis of the standing long jump

4. Discussion

The factors that influence the measurement of body compositions include physical activities, calorie consumption, age, and maturity(9). In this study, we found significant differencesin the weight, BMI, waist circumference, waist to height ratio, and subscapular skinfold thickness between genders in the elementary school age children with an age range between 7-11 years. A similar result from the Mexican children also showed that boys have higher z-BMI, waist circumference and waist to height ratio but was not significant (10). The study found that all three measurements were tools that can predict the lipidic cardio-metabolic risk factors, especially waist to height ratio ≥ 0.5 was betterfor detecting elevated LDL-c (10). In children, the greater BMI is correlated with greater height (11), this is the reason in this study boys had higher BMI because they were taller.

Waist circumference is used as the indicator for central obesity and related to risk factors of cardiovascular disease, meanwhile, skinfold thickness is related to both cardiovascular diseases and metabolic syndrome (9).

In this study we found that there was no significant difference of HGS between genders (Table.1). This finding is not similar to the study on Italian schoolchildren between the ages of 9-10 years (7), perhaps because the age range of our study is broader (7-11 years old) compared to the previous study.

We found moderate correlation (0.4 – 0.6) of HGS with age, weight, height, BMI, waist circumference, waist to height ratio, fat percentage, biceps, and subscapular skinfold (Table 2). This finding is similar to the previous study that showed an association between HGS and anthropometric indicators (7). Additionally, HGS also demonstrates significant correlation with all four anthropometric measurements (age, BMI, hand length, and forearm circumference) in a study conducted by Alahmari *et al* (8). There are several factors affect HGS performance, including sex, age, height, weight, and handedness. There is also correlation between SLJ and BMI. A previous study stated that BMI was significantly correlated with SLJ with p value < 0,001 (9).

Our study provides the value of HGS and SLJ in Indonesian children between the ages of 5-12. HGS and SLJ can be used as an index of physical fitness in children, especially the musculoskeletal component. Moreover, HGS and SLJ are useful as a predictor of neuromuscular disease and can be a predictor of mortality in youth.

Our study also demonstrates a greater maximal HGS in boys than in girls but there is no significant difference. These findings are similar to those of Italian schoolchildren between the ages of 9 to 10 years, where HGS value is 13.8 ± 4 for girls and 15.2 ± 3 for boys (3). The most important factor influencing HGS still seems to be gender or, specifically, sex hormones. In fact, fat-free mass, in turn, is linked to the sex hormones and is more represented in boys than in girls. In this regard, it is well known that sexual dimorphism in body composition is largely due to the action of sex steroid hormones. An important concept is that sex difference in body composition is manifested from fetal life and, in children, a significant difference in estradiol and testosterone is evident before the external signs of puberty appear, probably leading to a difference in HGS (7). But there is a different result for SLJ, where a higher value can be seen in girls compare to boys (p value<0.05).This finding is different from the study by Cakovec on 72 children between the ages 5-7 years that showed there was no effect of gender in SLJ (12). The results were different because there are other influencing factors including age and BMI (10).

5. Conclusions

The anthropometric indicators that are strongly determinant factors handgrip strength are age, weight, BMI, fat percentage, biceps, and triceps skinfold thickness. Meanwhile, for the standing long jump are gender, BMI and subscapular skinfold thickness.

6. Acknowledgements

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