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Research paper

The Comparison of Children's Anthropometrics and Motor Performance Relative Body Mass Index using Principle Component Analysis

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Abstract

This study aims to compare dominant factors of anthropometrics and motor component among children relative body mass index. A total 5819 primary school children (3243 boys and 2576 girls) aged 7.30±0.28 years old were subdivided into four groups according their Body Mass Index (BMI) namely underweight group (UWG), normal weight group (NWG), overweight group (OWG) and obese group (OBG). The parameters involved in this study are weight, height, standing broad jump (SBJ), sit and reach (SAR), hand wall toss (HWT) and 20 meter run (20MR). Method of Principle Components Analysis (PCA) was employed to ascertain the domain factors parameters for each BMI group. For boys and girls, initial PCA identifies two components with higher Eigen value (> 1). In first component VF1 for boys and girls, PCA after varimax rotation revealed two varifactors that are weight (> 0.90) and height (> 0.80) for all BMI group. Otherwise, second component VF2 for boys and girls revealed high factor loading on low muscular strength, hand-eye coordination and speed. This study indicates there is direct effect between motor proficiency and BMI among preschool population and revealed that primary school children with high body mass may have lower motor proficiency on explosive strength, coordination and speed compared with normal body mass.

Keywords: *Anthropometrics; Body mass index; Motor component; Principle component analysis*.

1. Introduction

Motor efficiency is used as a global term that includes terms used in literacy as basic motor skills or movement, motor skills or performance, motor skills and motor coordination. It can be described as one's ability to become proficient in various motor skills including locomotors, stability or manipulative movements. The involvement of children in physical activity is important for developing a healthy life and acquiring good motor skills. The age of children in preschool from four to six years is considered to be a great period for individual development and movement [1]. Most children at this age have been able to achieve object control and locomotor policies [2]. In addition, children also receive moderate and high motor skills and access to co-ordination of primary motor skills at the beginning of primary school [3]. Guidelines issued by the National Association of Americans recommend that children spend their time at least one hour per day to carry out physical activity and a few hours of non-structured activity (carrying out free activities). This activity should receive attention or guidance from qualified adults.

Physical fitness is defined as the ability of a person to perform daily tasks efficiently and physically without feeling overweight and has enough energy to carry out recreational activities [4]. Fitness is divided into two aspects namely physical fitness based on health and motor fitness. Physical fitness is used to demonstrate the five basic fitness components included muscle strength, muscle endurance, cardiovascular endurance, body composition and flexibility. While motor fitness is a more comprehensive term, it includes ten fitness components including the addition of five motor component performance so-called power, speed, agility, balance and reaction time [5]. Failure to maintain health will affect fitness cardiorespiratory, muscle function, agility, balance, and flexibility are related to health and fitness related to fitness component health [4].

Increased obesity rates have become a special focus of the health profession. Many children at overweight are more likely to become obese when they become adults [6]. This condition will increase the risk factors of cardiovascular disease such as hyper insulin, anaemia, diabetes, dyslipidaemia and hypertension. A person with excess weight will influence biology and cause low cardiorespiratory. Over the next twenty years, it is estimated that more and more people suffer from obesity [7]. For example, reports from the Centre for Health Education Unit in Hong Kong that stated that there is a pattern towards increasing obesity among primary school students in Hong Kong by 2.3% in 2004-2005 from 16.4% in 1997-1998 [8]. In addition, 9.5% of college students in the United States (USA) are classified as obese and 21.9% of them are considered to be overweight [9]. Meanwhile, a study

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among university students in China found that 2.5% of students were facing overweight and 0.4% of them were obese problem [10]. The rest 80.5% of students have normal BMI and 16.6% of them have underweight body mass.
This study purposely was carried out to compare dominant factors of children motor abilities according different body mass index for better understanding the strong and weakness of children body condition. Such finding would beneficial to parent when monitoring their children motor performance based on body mass index and also becomes valuable info for teachers when planning physical education activities, so that the effectiveness of that lesson at school can be enhanced.

2. Materials and Methods

2.1. Participants

A total 5819 students aged 7.30±0.28 years from 100 primary schools in Kedah, Malaysia were involved in this study. Among them, there are consist 3243 and 2576 students for boys and girls respectively. They were tested on two anthropometric components (weight and height); and four motor subscales which is power, flexibility, speed and coordination.

2.2. Testing Procedure

The anthropometric measurement and physical test data in this study were obtained from 3243 boys (aged 7.36±0.29) and 2576 girls (aged 7.37±0.29) in a sport development program in Kedah, Malaysia. All the participants were informed and their parents are required to fill out a consent form to participate in this program.

2.2.1 Anthropometrics

The anthropometric component of the participants included weight and height were measured before going through motor testing. For basic measurement (height and weight), the equipment used included a stadiometer and a weighing scale. Height characteristics were measured to the nearest 0.1cm, and mass characteristic was measured in kg. Height was measured from fingertip to fingertip while standing with the back to a flat wall and arms stretched with palms facing the investigator. The equipment required consisted of a tape measure on the wall, measured in centimetre (cm).

2.2.2. Standing broad jump

The participant stands behind a line marked on the ground with feet slightly apart. A two-foot take-off and landing is used, with swinging of the arms and bending of the knees to provide forward drive. The participant attempts to jump as far as possible, landing on both feet without falling backwards. Three attempts are allowed and the farthest was taken into account.

2.2.3. 20 meters' speed test

The test involves running a single maximum sprint over a set distance, with time recorded. After a standardized warm up, the test is conducted over 20 meters. The starting position should be standardized, starting from a stationary position with a foot behind the starting line, with no rocking movements. By using stopwatch equipment, the time to run each split distance were measured during the same run in second (s)

2.2.4. Sit and reach

This test involves sitting on the floor with legs out straight ahead. Feet with shoes off are placed with the soles flat against the box, shoulder-width apart. Both knees are held flat against the floor by the investigator, if required. With hands on top of each other and palms facing down, the participant reaches forward along the measuring line as far as possible. The reach is held for at least two seconds while the distance is recorded. Make sure there are no jerky movements and that the fingertips remain level and the legs flat. Readings must be recorded in multiples of 0.5 cm.

2.2.5. Coordination (Hand Wall Toss)

A mark is placed at 1 meter's distance from the wall. The person stands behind the line and facing the wall. The ball is thrown from one hand in an underarm action against the wall, and attempted to be caught with the opposite hand. The ball is then thrown back against the wall and caught with the initial hand. The test continued for 10 attempts. The number of throws that were caught will be recorded.

2.3. Statistical Analysis

2.3.1 Pre-processing data

A matrix set of boy group contains 19458 matrices data (6 variables × 3243 participants) and 15456 matrices data (6 variables × 2576 participants) for girl group were computed in this study. For matrices that have very small amounts of data lost (~ 3%) than the overall data recorded, the nearest neighbouring method can be used [11, 12]. This method examines the distance between each point and its nearest point. The nearest neighbouring method is the simplest method, where the endpoint of the gap is used as an estimate of all missing values.

2.3.2 Principal Component Analysis (PCA)

PCA is a common technique for finding patterns in data of high dimension [11, 13]. The idea behind of PCA is by which numbers of correlated variables are transformed into a smaller number of uncorrelated variables. The previous study applied PCA to provide indications for race walkers' classification and identified potentially important technical differences between higher and lowers skilled athletes [13, 14]. The factor loadings give idea on how much the variable has contributed to the factor; the larger the factor loading the more the variable has contributed to that factor [15]. Factor loadings are very similar to weights in multiple regression analysis, and they represent the strength of the correlation between the variable and the factor [16]. It can be used to compress a high dimensional dataset into a lower dimensional dataset. Recent study also revealed PCA is particularly useful when data on a number of useful variables has been gathered, and it is plausible that there is some redundancy in those variables [17].

3. Results and Discussion

Table 1 shows the descriptive statistics of anthropometric measurement and motor fitness among boys and girls student. It shows the summary statistics of mean and standard deviations for each parameters were taken into account in this study.
The measurement of sampling adequacy was measured using Kaiser-Meyer-Olkin (KMO). This test has been conducted to determine the adequacy of the sampling and also to make a reasonable interpretation based on the data collected. In addition, this test is conducted to ensure that each variable is unrelated to one another. The KMO value for boys indicates 0.54 which contributes to the adequacy of 54% sampling. Therefore, based on this result it is clear that no multi-co straight line observed between the original variable and which allowed us to proceed further with satisfactory analysis of the adequacy of sampling. The eigenvalues for the beginning of the PCA are shown in Figure 1. From that figure, it can be observed that for all groups of BMI among boys, PCA identifies two components as the most important because their higher eigenvalues are greater than 1 (> 1). This component is retained and used as an input variable for further analysis.

Table 1: Descriptive statistic of boy and girl students of primary school involved in this study

Variables	BMI Group	Boys			Girls	
		Mean	Std. Dev.		Mean	Std. Dev.
Weight (kg)	UWG	17.0	1.5		17.0	1.6
	NWG	21.0	2.4		21.0	2.5
	OWG	27.0	2.5		27.6	2.9
	OBW	34.0	4.7		32.6	5.9
Height (cm)	UWG	118.0	3.9		118.0	5.0
	NWG	119.0	5.0		119.0	4.9
	OWG	122.0	5.0		122.8	5.8
	OBW	125.0	5.2		124.0	6.4
SBJ (cm)	UWG	108.0	17.2		92.0	15.3
	NWG	110.0	16.5		94.0	15.2
	OWG	104.5	16.2		87.5	13.4
	OBW	94.0	15.7		88.0	12.9
SAR (cm)	UWG	26.0	4.2		25.8	4.3
	NWG	27.0	4.4		27.0	4.2
	OWG	26.8	5.0		27.0	4.7
	OBW	26.0	5.2		27.5	4.4
HWT (No.)	UWG	5.0	2.6		4.0	2.7
	NWG	6.0	2.7		5.0	2.7
	OWG	7.0	2.6		5.0	2.7
	OBW	7.0	2.7		5.0	2.7
20 M Run (s)	UWG	4.9	0.4		5.2	0.5
	NWG	4.8	0.4		5.1	0.4
	OWG	4.8	0.5		5.2	0.5
	OBW	5.0	0.4		5.2	0.5

In the current study, VFs with absolute values greater than 0.70 have been standardized as selection thresholds due to the fact that these values are relatively strong and stable, indicating a moderate and strong load on the extracted factor. It also has revealed different number of variables are satisfied with the threshold of loading 0.70 factors for different BMI groups shown in Table 2 and Figure 2. These variables are then classified as an important physical component which is particularly needed to identify the dominant motor treatment factor. Over all, all the groups have two factors (VF) that become the most important sources contributing child motor performance. There are two components of VF1 have fulfilled load factor 0.70, those are weight and height that show positive factor loading, it means the component is related to the child's motor skills for all body mass condition. Further result, will discuss the component of VF2 for each BMI group that will become the interest of this study. All the results were shown in Table 2.

For boys in UWG, it can be seen that two components of VF2 have fulfilled load factor of 0.70. The most important component after the varimax rotation were standing broad jump and hand wall toss. It can be seen from the VF1 and VF2 numbers that account about 54.14% of the total set data and variability of 27.09% and 27.05% respectively. For NWG, VF2 has identified one positive components and one negative component satisfying load factor 0.70 that is standing broad jump and 20 meter run respectively. The VF1 and VF2 figures that account for about 57.52% of the total set data and variability of 30.23% and 27.29% respectively. Next, result for OWG shows one positive high factor loading in VF2 that is standing broad jump. The total variability has count about 61.44% with 32.78% and 28.66% for VF1 and VF2 respectively. Lastly, OBW revealed almost similar with OWG. There is only standing broad jump parameter that satisfying load factor 0.70 in VF2 with 55.69% total of variability. It consisted of 27.27% and 27.82% variability for VF1 and VF2 respectively.

The KMO value for girls indicates 0.51 which contributes to the adequacy of 51% sampling. As previous explanation, this result is clearly shows that no multi-co straight line observed between the original variable and which allowed us to proceed further with satisfactory analysis of the adequacy of sampling. The eigenvalues for the beginning of the PCA are shown in Figure 2. From that figure, it can be observed that for all groups of BMI among girls, PCA also identifies two components as the most important because their higher eigenvalues are greater than 1 (>1). This component is retained and used as an input variable for further analysis.

Table 2: Factor loading after varimax rotation in PCA among boys

Parameter	UWG			NWG	
	VF1	VF2		VF1	VF2
Weight (kg)	0.88	0.05		0.95	0.05
Height (cm)	0.88	0.08		0.95	0.04
SBJ (cm)	0.2	0.74		0.05	0.77
SAR (cm)	-0.16	0.25		-0.03	0.43
HWT (No.)	-0.03	0.74		0.13	0.61
20 MR (s)	-0.09	-0.68		-0.05	-0.70
Eigenvalue	1.89	1.36		1.96	1.49
Variability (%)	27.09	27.05		30.23	27.29
Cumulative (%)	27.09	54.14		30.23	57.52
Parameter	OWG			OBG	
	VF1	VF2		VF1	VF2
Weight (kg)	0.98	-0.03		0.91	-0.12
Height (cm)	0.98	-0.02		0.89	0.08
SBJ (cm)	-0.09	0.81		-0.13	0.75
SAR (cm)	-0.19	0.53		0.05	0.52
HWT (No.)	0.12	0.56		0.14	0.64
20 MR (s)	-0.05	-0.68		0.07	-0.63
Eigenvalue	2.01	1.68		1.74	1.6
Variability (%)	32.78	28.66		27.27	27.82
Cumulative (%)	32.78	61.44		27.27	55.69

Comparison of BMI groups among girls also has discovered two factors (VF) that become the most important sources contributing child motor performance. Referring the result in Table 3, there are weight and height as two components in VF1 have fulfilled load factor 0.70 for all BMI groups. Both component show positive factor loading, that means such component is related to the child's motor skills for all body mass condition. For girls in UWG, it can be seen that two components of VF2 have fulfilled load factor of 0.70. They were standing broad jump with positive factor loading and 20 meter run with negative factor loading. It can be seen from the VF1 and VF2 numbers that account about 60.24% of the total set data and variability of 30.69% and 29.54% respectively. For NWG, VF2 also has identified positive components of standing road jump and negative component of 20 meter run satisfying load factor 0.70. The VF1 and VF2 figures that account for about 55.58% of the total set data and variability of 29.5% and 26.08% respectively. Next, result for OWG shows only one positive high factor loading in VF2 that is standing broad jump. The total variability has count about 58.23% with 32.52% and 25.71% for VF1 and VF2 respectively. Lastly, VF2 for OBW revealed two components that satisfying load factor 0.70. There is positive component of standing broad jump and negative component of 20 meter run. The total of 55.69% variability of 27.27% and 27.82% variability for VF1 and VF2 respectively.

Discussion on domain factors of anthropometric attributes and motor abilities relative BMI groups give important information related to children body health. For children with underweight and normal body mass, they are willing to perform better in strength and speed test. Otherwise, looking at the relation of overweight and obesity with fitness performance, we further found that overweight demonstrated body mass significantly can effect explosive strength and speed performance. This is major effect of excess body weight where their explosive strength and ability to speed up become low. For boys and girls, children with normal body mass have better performance in explosive strength, coordination and speed than obese boys did. This is important for the weight management program of children. Since BMI increases naturally with age, maintenance or attenuation of the increase in BMI should be considered as success. The modest decrease in BMI, which causes a change from obesity to overweight BMI, will be accompanied by significant improvements in fitness performance.

Table 3: Factor loading after varimax rotation in PCA among girls

Parameter	UWG			NWG	
	VF1	VF2		VF1	VF2
Weight (kg)	0.96	0.04		0.93	0.03
Height (cm)	0.96	0.15		0.93	0.04
SBJ (cm)	0.01	0.83		0.02	0.78
SAR (cm)	0.03	0.41		-0.01	0.45
HWT (No.)	0.01	0.63		0.13	0.52
20 MR (s)	-0.06	-0.72		-0.08	-0.71
Eigenvalue	1.90	1.71		1.90	1.44
Variability (%)	30.69	29.54		29.5	26.08
Cumulative (%)	30.69	60.24		29.5	55.58
Parameter	OWG			OBG	
	VF1	VF2		VF1	VF2
Weight (kg)	0.98	0.02		0.93	-0.07
Height (cm)	0.98	0.02		0.93	0.09
SBJ (cm)	-0.02	0.81		-0.19	0.73
SAR (cm)	-0.07	0.44		0.09	0.42
HWT (No.)	0.04	0.56		0.21	0.58
20 MR (s)	-0.15	-0.62		-0.08	-0.75
Eigenvalue	1.98	1.52		1.86	1.59
Variability (%)	32.52	25.71		30.3	27.14
Cumulative (%)	32.52	58.23		30.3	57.44

Note: UWG = Underweight Group; NWG = Normal Weight Group; OWG = Overweight Group OBG = Obese Group; SBJ = Standing Broad Jump; SAR = Sit and Reach; HWT = Hand Wall Toss; 20 MR = 20 Meter Run

Regarding the influence of childhood obesity on fitness profile the results of the present study revealed that overweight and obesity were indicative of poorer cardiorespiratory and motor fitness in both genders. More specifically, overweight and obese children, compared to their normal-weight counterparts, demonstrated inferior performance in most studied parameters, except flexibility. These associations were partly independent of age and height, but strongly influenced by body weight, since adjustment for this variable decreased substantially the differences among the groups. These data are consistent with studies conducted among schoolchildren, showing that overweight and obesity was inversely related to several components of motor [16, 18] and health-related fitness parameters, such as cardiorespiratory fitness [19, 20]. Current finding also has found that flexibility did not highly contributed among the four BMI categories. This concordance with previous study that mentioned there no significant effect of flexibility when comparing different BMI group [18].

A significant amount of fitness test performance is explained by heredity. However, this impact is thought to be relatively small, accounting for less than 30% of the differences between people [21]. Thus, enhanced fitness performance mostly reflects the level of habitual physical activity. Indeed, studies in children have indicated that high physical fitness scores, especially high levels of cardiorespiratory fitness, are associated with increased levels of physical activity [22]. Consequently, the significant differences in fitness performance observed between normal weight and overweight/obese children, could be partially attributed to differences in physical activity levels.

Poor cardiorespiratory fitness joined with excess body fat and the associated sedentary lifestyle are significant predictors of developing coronary heart disease [23]. There is also strong evidence that low cardiorespiratory fitness results in a higher risk of later obesity in growing prepubertal children [24]. This may be explained by the fact that low cardiorespiratory fitness levels reduce muscular fat oxidation capacity, which may decrease the tolerance of dietary fat and increase body weight and fatness [25]. These findings emphasize the importance of increasing or maintaining cardiorespiratory fitness as an intervention for preventing the development of obesity in children. Since moderate to vigorous physical activities result in greater changes in cardiorespiratory fitness than low intensity activities, they should be encouraged both within families and at schools.

In conclusion, and within the study's limitations, the present data revealed a high prevalence of overweight and obesity observed in primary schoolchildren. Overweight and obesity were indicative of a more adverse fitness profile in both genders; however, a shift from the upper (obese) to the intermediate BMI category (overweight) could be accompanied by significant fitness improvements. Given that obesity and poor cardiorespiratory fitness have been identified as risk factors for better motor skills development, the present data suggest that interventions promoting children's activities should ideally involve measures that simultaneously improve fitness and lower fatness and should begin early in life.

4. Conclusion

As the conclusion, these finding concluded the criterion describing physical and motor performance among children according to groups assigned by body mass index. For all BMI groups, weight and height were the highest contribution in describing physical criteria among children. Underweight children have possibility to show variation in coordination compared to other groups. Children with normal weight have the tendency to show high performance in muscular strength and speed. Meanwhile, children in overweight and obese group tends to have low muscular strength and power of the lower body (standing broad jump) and also speed (20 meter run). There also discovery flexibility of the lower back and hamstring muscles are unrecognized features at this level of age.

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