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Relationship between Anthropometric Profiles and Performance of Gymnastics Athletes

Helmy Firmansyah[1], Tri Martini[1], Rion Hendrianto[2]

[1]Physical Education Study Program, Univeristas Pendidikan InIndonesia, Indonesia
[2]Postgraduate, Sports Education, Univeristas Pendidikan InIndonesia, Indonesia

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Abstract

Gymnastics is one of the sports requiring the right composition of body posture to support its best performance. For this reason, coaches and athletes should know anthropometric profiles to improve their performance in championships. This study aimed to analyze the correlation between anthropometric profiles and the performance of gymnastics athletes. This research is correlation research involving 17 youth gymnastic athletes in West Java (average age of 19.7). The sampling technique used the saturated sampling technique. The instruments included anthropometric measurement tests and gymnastics performance tests referring to the Code of Points (COP) set by the International Federation of Gymnastics (FIG). The results showed that there was a significant correlation between anthropometric profiles and the athlete performance. The correlation analysis results of anthropometric variables were height of 0.678, weight of 0.487, BMI of -0.777, LiLA of 0.605, and abdominal circumference of -0.513. The results obtained the significance level of height on exercise performance of .003 < 0.05, body weight on exercise performance of .047 < 0.05, BMI on exercise performance of 0 < 0.05, upper arm circumference on exercise performance of .010 < 0.05, and circumference of abdomen on exercise performance of .035 < 0.05. This study concludes that there is a significant correlation between anthropometric profiles and the performance of gymnastics athletes.

✉ Correspondence Address : Jln Dr. Setiabudi 200, Bandung, Indoneisa
E-mail : helmy.firmansyah@upi.edu

INTRODUCTION

Gymnastics is one of the hardest games intertwining science and technology to improve the performance of the players. The scientific principles and concepts, such as "therbligs", require not only innate amounts of strength, but also grace, flexibility, endurance, balance, speed, control, and mental strength (Tandon, 2014). In addition, gymnastics also involves exercises that demand strength, flexibility, balance, agility, endurance, and control (Poblano-Alcalá & Braun-Zawosnik, 2014). Gymnastics requires excellent physical conditions, because it requires strength to support a person own body and move it in a systematic order. In this case, of course, the physical aspect is the most dominant factor, which is directly related to a person physical condition, such as body posture, body structure, weight, and body compositions (Hambali & Suwandar, 2019).

Physical activity is closely related to anthropometrics (Mulyadi, 2013). Anthropometrics has relationships with appearance and movement skills of athletes, including in soccer athletes, swimming athletes, and gymnastics athletes (Mkaouer et al., 2018) (Barbara Vandorpe et al., 2012). In general, there are certain sports that require anthropometric excellence to support optimal movement and performance skills. Body composition, for athletes and people in general, is used to describe the percentage of fat, bone, and muscle in the human body. Because muscle tissue occupies less space in our body than fat tissue, our body composition and weight determine slimness (Jeukendrup & Cronin, 2010). The human body consists of 4 components, namely fat, protein, water, and inorganic salts, while the proportion of which is an important measure of physical health standards (Brown et al., 2006; Xu et al., 2009). Physical parameters, such as stature, body mass, and fat/muscle mass or somatotype components, can affect performance and success in competitions in addition to other factors such as athlete genetics, physical fitness, motor skills, and mental skills of the tactical training or anthropometric profiles (Martín-Matillas et al., 2014).

In general, the anthropometric profile and body composition of gymnasts are characterized by low body mass, little fat mass, long extremities, and small and thin body and hips (Boros, 2009; Haase, 2011). Anthropometrical assessment helps improve the understanding of the gross functioning of the human body by measuring the body size, shape, proportion, and composition (Muqarram, 2015). Body characteristics is important for gymnastics athletes to improve their performance and competitive success (Klentrou & Plyley, 2003; Krentz & Warschburger, 2013). In competitive gymnastics, coaches and athletes regard low body weight as an important requirement for performance (Kaur & Koley, 2019). The profile of the gymnast is described as short stature, with shorter lower leg length, minimal subcutaneous fat tissue, greater skeletal-muscle development in the upper body, long arms, narrow pelvis, and highly mesomorphic (Daly et al., 2000; Irurtia Amigó et al., 2009). This corresponds to the standard reference of high-level female gymnasts, characterized by a shorter stature, lighter body weight, wider shoulders, relatively small hips, ecto-mesomorphic somatotype, low body fat, high amount of lean body mass, and slower pubertal maturation than that observed in other gymnast age peers (Beunen et al., 2015; Claessens et al., 1991; Malina et al., 2013).

Anthropometric characteristics significantly influence the success of gymnasts and can be a valuable value and a determinant of the success of their performance (Vandorpe, 2011). Other studies have shown that, in addition to skills, training, motivation, psychological factors, and physiological and biomechanical demands, many anthropometric compositions, such as body size, body shape, and body type, contribute to the improvement of an athlete performance (Miletić et al., 2004).

The contribution of age, height, body mass, circumference, and diameter shows significant results in all rhythmic, aerobic, and artistic gymnasts (Douda et al., 2007). Gymnasts, in their development period, induce exercise stress on the cardiovascular and musculoskeletal systems which involve changes in body size and physiological characteristics side by side. Since skeletal maturity during growth correlates quite well with height, weight, and other indices of physical development, gymnast athletes have wider shoulders, narrow hips, long and slender upper and lower limbs, very low body fat and show a symmetrical value in sitting ratio and standing height (Douda et al., 2007).

In conclusion, there is a lot of evidence showing that there is an influence of the anthropometric profile of gymnastics athletes on their performance. However, the research in gymnastics mostly studies gymnastics athletes and performance in general. For this reason,

this research is expected to provide benefits and input for gymnastics coaches and athletes and also become materials for improving the achievement in gymnastics.

METHODS

Participants

The method used in this research was the correlation method. The population of this study was the West Java Youth Gymnastics Athlete, involving 17 athletes (10 female athletes and 7 male athletes). The sampling technique used the saturated sampling technique.

Instrument

Anthropometric Measurement Tests

Measuring body weight in sports is important for assessing body compositions and for monitoring changes in weight following the diet and exercise. Measuring body mass can be valuable for monitoring body fat or muscle mass changes as well as for monitoring hydration levels.

The measurement of height, from the feet to the top of the head, is a standard component of most fitness assessments. Height (or lack of height) is an important attribute for many sports. Standing height is the measurement of the maximum distance from the floor to the highest point of the head when the subject is facing directly ahead. During the measurement, shoes should be off, feet together, and arms by the sides. Heels, buttocks, and the upper back should also be in contact with the wall when the measurement is made.

Skinfold measurement is a technique to estimate the fat in the body. It involves the use of a device called a caliper to lightly pinch the skin and underlying fat in several places. This quick and simple method of estimating body fat requires a high level of skill to get accurate results.

Body mass index (BMI) is a measure of weight adjusted for height, calculated as weight in kilograms divided by the square of height in meters (kg/m2). Although BMI is often considered an indicator of body fat, it is a surrogate measure of body fat because it measures excess weight rather than excess fat. Despite this fact, studies have shown that BMI is correlated to more direct measures of body fat, such as underwater weighing and dual energy x-ray absorptiometry.

Exercise Performance Tests

The Code of Points (COP) set by the International Federation of Gymnastics (FIG) was used. Score for each gymnast is determined by adding together the score for the routine content (Difficulty Score) and the execution (Execution Score). Each routine is given a start value. The actual score is the total of credit given for the routine minus deductions for execution. The Difficulty Score reflects the total difficulty value (DV) of skills plus the connection value (CV) and compositional requirements (CR) (https://www.gymnastics.sport/site/rules/).

Procedure

In the height measurement, client first stands with heels, buttocks, and upper back against stadiometer. Weight should be evenly distributed on feet, with shoulders relaxed, legs straight, and arms at sides. The next step is asking the client to look straight ahead and making sure the client is standing flat on their feet. The client hands should not be in their pockets or resting against the stadiometer. To ensure the highest point on the skull is measured, the client head has to achieve a Frankfort plane. Then, the client stands up straight, with the L board rested on top of the client head, making sure that it forms a right angle with the measurement rod. At eye level, the measurement to the nearest ½ in is recorded. The measurement should always be taken from the side of the stadiometer. The equipment needed includes stadiometer, pen/pencil, and recording form.

In weight measurement, the scale is placed on a hard floor level surface without carpet or rugs of any kind. If hard floor is unavailable, place the scale on a board. The scale should be set up in a private place, away from objects such as walls or tables so people will not be able to lean on them. Program the scale to kilos mode. Check the scale to make sure it reads zero. Have client remove heavy outer clothing and items from pocket. Before athlete steps on the scale platform, make sure the scale reads zero. Ask athlete to stand on the scale without moving. Record the weight measurement. Tell athlete to step off of the scale. The equipment needed includes digital scale, pen/pencil, and recording form.

BMI is calculated by taking a person weight divided by their squared height using the metric units. For instance, if the height is 1.82 meters, the divisor of

the calculation will be (1.82 * 1.82) = 3.3124. If your weight is 70.5 kilograms, then your BMI is 21.3 (70.5 / 3.3124). Using pounds/kilos and inches/cm, BMI can be calculated by multiplying a conversion factor of 703, so BMI = weight (lb) / [height (in)]2 x 703.

The skinfold measurement is firstly conducted by grasping the skinfold firmly between your thumb and index finger of your left hand. The skinfold is lifted 1 cm and recorded with the calipers held in the right hand. Keep the fold elevated while the measurement is recorded. Take the skinfold measurement 4 seconds after the caliper pressure is released.

Data Analysis

To test the contribution of independent variables, descriptive statistical analysis techniques and hypothesis tests were administered by using the Statistical Product for Social Science (SPSS) 25 program. The process of data analysis involved normality test using Shapiro Wilk, homogeneity test using Levene statistics with a significance level of = 0.05, and hypothesis testing using the Pearson Product Moment Correlation.

RESULT

Based on the results of the research conducted, the researchers found various data that were ready to be processed, analyzed, and concluded. The data regarding the demographics of artistic gymnastics athletes and rhythmic gymnastics athletes are presented in Table 1.

The results of the normality test using the Shapiro-Wilk test showed that the height had a sig value of 0.926 > 0.05, weight had a sig value of 0.911 > 0.05, BMI had a sig value of 0.077 > 0.05, LiLA had a sig value of 0.546 > 0.05, abdominal circumference had a sig value of 0.208 > 0.05, and performance had a sig value of 0.265 > 0.05. Therefore, it can be concluded that the anthropometric data and the performance of the gymnastics athletes in this study were normally distributed and could be analyzed using parametric tests. The results of the homogeneity tests. The height gained a significance value of 0.394 > 0.05. The weight gained a significance value of 0.886 > 0.05. The BMI obtained a significance value of 0.773 > 0.05. LiLA had a significance value of 0.633 > 0.05. The abdominal circumference got a significance value of 0.092 > 0.05. The performance gained a significance value of 0.687 > 0.05. Therefore, all of the variable data were said to be homogeneous.

Table 1. Gymnastics Athlete Demographics

Height	Weight	BMI	UAC	AC	Performance
156	50	20,5	28	65	11,7
162	58	22,1	29	69	12,85
165	56	20,6	26	66	13,4
156	55	22,6	26	75	10,6
161	50	19,3	28	59	12,5
154	52	21,9	28	66,5	11,8
152	50	21,6	26,5	66,5	11,25
166	60	21,8	28	63	13,2
159	59	23,3	29	61	12,85
157	54	21,9	27	76	10,15
160	48	18,8	27	67	12
158	53	21,2	27	65	12,6
163	55	20,7	30	66	13,4
155	46	19,1	24	65	10,4
161	53	20,4	26	68	12,15
160	56	21,9	28	70	12,95
160	57	22,3	27	67	11,2

Table 2. Pearson Product Moment Correlation Test

Variable	Correlation	PPM	Contribution	p-value
	R	R^2		
Height –	0.678	0.46	46%	.003
Weight –	0.487	0.24	24%	.047
BMI –	-0.777	0.60	60%	0
UAC –	0.605	0.37	37%	.010
AC -	-0.513	0.26	26%	.035

*. Correlation is significant at the 0.05 level (2-tailed).

Based on the results of the Pearson product moment correlation test (table 2), there was a significant functional positive correlation between height and gymnastic performance. The analysis found a correlation of r = 0.678 with a p-value of 0.003, meaning that height and exercise performance had a strong and significant positive relationship. There was also a significant functional positive correlation between weight and gymnastic performance. The analysis found a correlation of r = 0.487 with a p-value of 0.047, showing that the body weight and the performance of gymnastics athletes had a strong and significant positive relationship. Furthermore, there was also a significant functional correlation between Upper Arm Circumference and gymnastic performance. A correlation of r = 0.605 with a p-value of 0.010 was found, indicating that the Upper Arm Circumference and the performance of gymnastics athletes

had a strong and significant positive relationship.

Meanwhile, a significant functional negative correlation was apparent in BMI and exercise performance. The analysis found a correlation of r = -0.777 with a p-value of 0, concluding that the BMI and the performance of gymnastics athletes had a strong and significant negative relationship. Similarly, a significant functional negative correlation was found in the Abdominal Circumference with gymnastic performance. The analysis found a correlation of r = -0.513 with a p-value of 0.035, concluding that the Abdominal Circumference and the performance of gymnastics athletes had a strong and significant negative relationship.

DISCUSSION

The analysis results showed that the correlation between height and exercise performance was r = 0.678 with a p-value of 0.003 and the determination coefficient of 0.46, meaning that there was a contribution of 46%. Therefore, the correlation between height and exercise performance showed a strong and significant correlation. Thus, the researchers concluded that there was a positive functional correlation between height and exercise performance. Biological aspect in terms of body posture structures, including height, is one of the determinants of achieving ability in sports. Various anthropometric compositions, such as body size, body shape, and body types, are responsible for contributing to the improvement of an athlete performance (Mohammad & Islamia, 2016). Age, height, body mass, circumference, and diameter also have a contribution on significant results in all rhythmic, aerobic, and artistic gymnasts (Douda et al., 2007).

Regarding the correlation between body weight and exercise performance, the result of analysis found r = 0.487, p-value of 0.047, and the determination coefficient of 0.24, meaning that there was a contribution of 24%. Therefore, the correlation between height and exercise performance was fairly strong and significant. The researchers concluded that there was a positive functional correlation between body weight and exercise performance. Low body mass seems to be a real advantage when performing skills that require movements with complex routines (Kaur & Koley, 2019). For example, the physique of elite gymnasts is characterized by small size and low body mass, with a predominance of ecto-mesomorphy, low fat mass, and late maturity (Bacciotti, 2017). In addition, a lower body weight can be associated with better performance in sports (de Oliveira et al., 2021).

Another result of the analysis prevailed that the correlation between BMI and exercise performance was r = -0.777 with a p-value of 0 and the determination coefficient of 0.60, indicating that there was a 60% contribution. For this reason, the correlation between BMI and exercise performance was strong and significant. The researchers concluded that there was a negative functional correlation between BMI and exercise performance. The results of this study proved that there was a negative functional correlation between BMI and exercise performance, showing that the higher the BMI, the lower the exercise performance. Body mass index, in various studies, can affect the quality of a person health. Athletes with inappropriate BMI will not be able to display maximum performance (Hambali & Suwandar, 2019). The results of data analysis described that the average Body Mass Index (BMI) of West Java Youth Athletes was 21.2 kg/m2, falling in the normal BMI category. It indicates that gymnastics athletes are required to have an ideal body posture, so that later they can perform a maximum performance.

Regarding the correlation between LiLA and exercise performance, the analysis found r = 0.605 with a p-value of 0.010 and the determination coefficient of 0.37, meaning that there was a contribution of 37%. Therefore, LiLA and exercise performance had a strong and significant correlation. Thus, the researchers concluded that there was a positive functional correlation between LiLA and exercise performance. The measurement of the upper arm circumference is considered to represent the current weight condition (Sareen Annora Stepnick Gropper; Jack L Smith, 2013). Upper arm circumference has a high level of sensitivity to changes in body weight. Otherwise, arm circumference will decrease along with weight loss (Cattermole et al., 2017). The enlarged upper arm circumference will affect body weight. The increased weight will hamper the athlete performance when competing.

The last, the result of analysis also showed that the correlation between abdominal circumference and exercise performance was r = -0.513 with a p-value of 0.035 and the determination coefficient of 0.26, indicating a contribution of 26%. Thus, the correlation between

height and exercise performance was fairly strong and significant. For this reason, the researchers concluded that there was a negative functional correlation between abdominal circumference and exercise performance. The results of this study proved that there was a negative functional correlation between abdominal circumference and exercise performance. It indicates that the higher the abdominal circumference, the lower the exercise performance. As found in previous research, the contribution of abdominal circumference showed significant results in all gymnasts (Kaur & Koley, 2019).

CONCLUSION

Based on the results of data analysis and research findings that have been carried out, there was a positive functional correlation between height, body weight, upper arm circumference and performance and a negative functional correlation between BMI, abdominal circumference, and performance of gymnastics athletes.

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CONFLICT OF INTEREST

The authors declared no conflict of interest.

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