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Relationship between Jump Distance for Running Long Jump and Physical Characteristics of Male Students in PE Class

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Abstract

The study aims to examine the relationship between physical characteristics and jump distance in running long jump among male college students in PE classes. The study recruited 146 healthy male students aged 17 - 18 years who attended PE classes on running long jump. Multiple regression analysis was carried out to examine the extent to which physical characteristics account for variances in jump distance. To compare the contribution of anthropometric parameters, a 50-meter run time was added to the analysis as an independent variable. Analysis revealed that 50-meter run time, obviously, largely accounted for variance in jump distance. Additionally, body mass and percentage of body fat were adopted as significant independent variables. Using another combination of independent variables for analysis, lean body mass and fat mass were found to be significantly independent variables. Therefore, results suggest that appropriate control of body composition in male students will not only be beneficial for their health but also be associated with jump performance in running long jump.

Keywords

Jump Distance, Physical Education, Running Long Jump, Track and Field

1. Introduction

Running long jump is a unique event in track and field, which combines running and jumping. It also integrates approach-run, takeoff, air posture, and landing. In addition, it is recognized as a closed-skill type sprint/power event. After taking off from the ground, the body remains unaffected by any external force except for air resistance. For this reason, the center of mass pertains to trajectory in the air with physical principles (projectile motion) and the landing point is determined at the moment of takeoff (Fukashiro, 1983). For this reason, many studies on takeoff skills have been conducted from the viewpoints of kinematics and kinetics (Hay, 1986; Hay, et al., 1986). In addition, the relationship between approach-run speed and jump distance has been discussed because the required horizontal speed for jumping is led by approach-run (Hay, 1986; Hay, Miller, & Canterna, 1986; Lee, Fowler, & Derby, 1994).

Physical resources that develop approach-run speed and takeoff power are recognized as important determinants of jump distance as well as jumping skills. In other words, speed or power is one expression of structural physical resources or a set of physical characteristics (i.e., stature, body mass, and body composition). Specifically, previous studies proposed that lean body mass is associated with muscle mass, and fat mass, which implies an inert substance, acts similarly to weights (Azuma, Maezawa, & Kawakami, 2000; Miyatake, Miyauchi, Nishikawa, Saito, & Numata, 2007). Thus, physical characteristics, such as body composition, pertain not only to simple dimensional parameters but also structural physical resources.

Conversely, running long jump is one of the PE materials, that is widely utilized in primary and secondary education. Learners are apparently different from athletes in terms of physical fitness. In addition, learners may vary not only in sprint ability or jumping skills but also physical characteristics. In other words, learners' jump performance may be influenced by not only sprint ability or jumping skill but also structural physical resources. Hence, identifying the relationship between physical characteristics and jump performance can provide useful information on teaching running long jump.

Therefore, the study aims to determine the relationship between the physical characteristics of male students and their jump distance in running long jump during PE classes.

2. Methods

2.1. Subjects

The subjects were 146 healthy college male students aged 17 - 18 years (stature: 169.8 ± 11.6 cm; body weight: 59.9 ± 8.1 kg; %fat: 25.6 ± 3.3%). All participants declared no previous leg injuries. Informed written consent was collected from the subjects, who were briefed about the aim and procedure of the study and its potential for publication. The Research Ethics Committee of the National Institute of Technology, Fukui College approved the study (Permission numbers: 29-1, 30-1, and 30-2).

2.2. Procedure

The subjects attended five consecutive PE classes for running long jump (days 1 - 5, 90 min each). Jump distance with their maximal efforts was measured on day 4 or 5. Instruction for a series of fundamental skills, such as approach-run, takeoff, air posture, and landing, was provided for every stage. Adequate time was allocated for practice in setting the distance of approach-run and takeoff movements. Prior to instruction or practice, 50-meter run time (50-m RT) and percentage of body fat (%fat) were measured. A bioimpedance method using eight electrodes and two frequencies (TANITA, RD-800) were used to measure %fat. In addition, lean body mass (LBM) and fat mass (FM) were calculated.

2.3. Statistics

Under the assumption that linear and additive relationships exist between jump distance and anthropometric parameters (i.e., physical characteristics or body composition), multiple regression analysis (stepwise method) was carried out to obtain the regression equation. To avoid multicollinearity, two combinations of independent variables, namely, 1) stature, body mass, %fat, and 50-m RT and 2) stature, LBM, FM, and 50-m RT, were used for analysis (following Azuma & Anada, 2013). As previous studies reported a negative correlation between jump distance and 50-m RT (Azuma & Matsui, 2018; Azuma & Matsui, 2019; Matsui & Azuma, 2019), 50-m RT was added as an independent variable for comparison with anthropometric parameters. Although the highest correlation coefficient (r = 0.614) was observed between body mass and %fat in independent variables, its variance inflation factor (VIF = 1.605) did not exceed 10. Therefore, multicollinearity is not a problem in the analysis. A P-value < 0.05 indicated statistical significance.

3. Results

Table 1 and **Table 2** present the results of multiple regression analysis. In both combinations of the independent variables, stature was not adopted as a significant independent variable ($P > 0.05$). The standard regression coefficients indicated that 50-m RT exerted the largest influence on jump distance. The regression equation in the combination of the independent variables for BM, %fat, and 50-m RT is presented as follows:

$$\text{jump distance} = 9.22 \times 10^{-3} \times \text{BM} - 29.4 \times 10^{-3} \times \%\text{fat} \\ - 0.556 \times \text{50-m RT} + 8.268.$$

Table 1. Multiple regression analysis for determining jump distance in stature, body mass, %fat, and 50-m run time.

Independent variable	Regression coefficient	Standardized regression coefficient	Partial F-value	r^2	F-value
Stature (cm)	n.s.	n.s.	n.s.		
Body mass (kg)	9.22×10^{-3}	0.194	7.0*		
%fat (%)	-2.94×10^{-3}	−0.318	15.5*		
50-m run time (s)	−0.556	−0.595	86.9*		
Constant	8.268		278.6*	0.565*	61.5*

*$P < 0.05$. r^2 is the coefficient of determination of the regression model. n.s. indicates no significance.

Table 2. Multiple regression analysis for determining the jump distance in stature, lean body mass, fat mass, and 50-m run time.

Independent variable	Regression coefficient	Standardized regression coefficient	Partial F-value	r^2	F-value
Stature (cm)	n.s.	n.s.	n.s.		
Lean body mass (kg)	12.5×10^{-2}	−0.205	8.2*		
Fat mass (kg)	-18.7×10^{-2}	0.180	7.0*		
50-m run time (s)	−0.556	−0.596	75.4*		
Constant	7.946		172.3*	0.540*	57.8*

*$P < 0.05$. r^2 is the coefficient of determination of the regression model. n.s. indicates no significance.

The three abovementioned variables accounted for 56.5% in total of the variance in jump distance ($r^2 = 0.565$, $P < 0.05$). Calculating using the standard regression coefficients and coefficient of determination (r^2), on average, BM accounted for 9.9% ($0.194 \times 0.565 \times 100/(0.194 + 0.318 + 0.595)$), %fat for 16.2%, and 50-m RT for 30.4% of variance in jump distance.

Conversely, the regression equation in the combination of independent variables for LBM, FM, and 50-m RT is presented as follows:

$$\text{jump distance} = 12.5 \times 10^{-2} \times \text{LBM} - 18.7 \times 10^{-2} \times \text{FM} - 0.556 \times \text{50-m RT} + 7.946.$$

The three abovementioned variables accounted for a total of 55.0% of variance in jump distance ($r^2 = 0.550$, $P < 0.05$). Calculating using the standard regression coefficients and coefficient of determination, on average, LBM accounted for 10.1% ($0.194 \times 0.565 \times 100/(0.194 + 0.318 + 0.595)$), FM for 11.5%, and 50-m RT for 33.4% of variance in jump distance.

4. Discussion

The %fat was measured using a bioimpedance-type body composition analyzer equipped with eight electrodes and two frequencies. Previous studies reported that eight electrodes devices are more accurate than four for evaluating body fat (Pietrobelli, Rubiano, St-Onge, & Heymsfield, 2004). And no significant difference in body fat evaluation was observed between the two-frequency technique and the dual energy X-ray absorptiometry method (Alves, Souza, Biolo, & Clausell, 2014). Therefore, %fat was considered accurately measured in this study.

Referring to previous studies on the positive correlation between approach-run speed and jump distance (Hay, 1986; Hay, Miller, & Canterna, 1986; Lee, Fowler, & Derby, 1994) and negative correlation between 50-m RT and jump distance (Azuma & Matsui, 2018; Azuma & Matsui, 2019; Matsui & Azuma, 2019), this study naturally considered that 50-m RT largely contributed to jump distance. Evidently, a large horizontal speed is an important factor for increasing jump distance. In general, 50-m RT expresses sprint ability, and determines approach-run speed. In addition, the literatures have pointed to the fact that the horizontal speed of approach-run influences jump distance (Hay, 1986;

Hay, Miller, & Canterna, 1986; Lee, Fowler, & Derby, 1994). In the same manner, this study attributes the large contribution of 50-m RT to jump distance.

Alternatively, although body mass and %fat were significant independent variables, %fat contributed more to jump distance than body mass (16.2% vs. 9.9%). In addition, the signs of the regression coefficients for %fat and body mass were positive and negative, respectively. This finding indicated that jump distance tended to be greater with smaller %fat. In other words, a body composition that consists of less fat and more LBM contributes to jump distance. In fact, both variables were found to be significant as independent variables in the abovementioned combinations of variables that included them. The reason for the positive sign of the regression coefficient for body mass may be explained by the relatively greater LBM compared with FM.

LBM is regarded as a structural physical resource for developing muscle strength/power (Davies, 1971; Temfemo, Hugues, Chardon, Mandengue, & Ahmaidi, 2009). In running long jump, a great takeoff power and a fast running speed are required to increase jump distance. In addition, muscle mass for developing muscle strength/power is essential for longer jump distances. The sign of the regression coefficient for LBM was positive, which indicated that greater muscle mass will be advantageous for jump distance. Hence, LBM was deemed associated with powerful takeoff.

Furthermore, the sign of the regression coefficient for FM was negative, where greater FM was considered disadvantageous for increasing jump distance. FM is an inert substance, and plays the role of a weight. Also, the extent of contribution of FM to jump distance was similar to that of LBM. Although LBM and FM served different functions, they provided the same extent of contribution to jump distance.

The findings demonstrated that body mass and body composition, not stature, were factors associated with jump distance in running long jump. Although the extent of the association of such variables with jump distance were relatively small compared with sprint ability, the results suggested that improving body composition will be beneficial not only for health but also for training purposes, which may influence jump distance in running long jump for male college students in PE class.

5. Conclusion

The study investigated the relationship between jump distance in running long jump and physical characteristics and body composition of male students in PE class using multiple regression analysis. The results revealed that body mass and %fat were adopted as independent variables, although 50-m RT was the greatest contributing variable to jump distance. In addition, this study identified that LBM and FM are advantageous and disadvantageous to jump distance, respectively. Thus, this study suggests that body composition would play a significant role in running-long jump performance among male students.

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This study was reanalyzed by adding subjects that were presented by Azuma and Matsui in the 2018 Annual Meeting of the Japan Ergonomics Society, Kansai Branch. Moreover, according to Azuma & Anada (2013), this study was reconstituted by further analysis based on different viewpoints from a group of independent variables (i.e., stature, body mass, and %fat).

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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