LONG JUMP: THE ARE BODY HEIGHT AND BODY WEIGHT GOOD PREDICTORS OF PERFORMANCE IN ELITE JUMPERS?

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ABSTRACT

KEY WORDS: anthropometric characteristics, elite jumpers, influence, long jump.

Background: Long jump are cyclic-acyclic movements of maximum intensity. It is a discipline that combines speed and jump in technique, that is, the speed-strength properties of competitors. Speed, agility and explosiveness are of special importance in jumpers. The **main goal** of the research is to determine the influence of Body height (BH) and Body weight (BW) with the best achieved results of Long jump. **Material and methods**: In study included 21 top male jumpers (BH=184.19±4.68cm; BW=78.86±6.81kg). Their achieved best results were analyzed. Pearson correlation coefficient was used to determine the relationship between body height and body weight and the results of long jumpers. Univariate model of regression analysis was applied and the relevant coefficients were calculated. The level of acceptance of statistical significance was set to $p<0.05$. **Results**: Simple regression analysis did not show a statistically significant effect of Body height on the results in the long jump (BH vs. Long jump $R=0.183$; $p>0.05$), while Body weight confirmed a significant inverse relationship with the results of the jump (BW vs. Long jump $R= -0.442$; $p<0.05$). **Conclusion**: Long jumpers contain a large percentage of active muscle mass that integrates and generates motor explosive abilities for the success of long jumpers, primarily strength and speed, which is confirmed by the results of the study. However, a good jump technique is also necessary, but with optimal body weight, because any increase in weight has a negative effect on the length of the long jump.

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INTRODUCTION

Athletic jumps belong to cyclic-acyclic movements, where the distance and height of the body's ascent are conditioned by the initial velocity (Vo) and the angle of ascent (α) body of gravity to be directed at the most favorable angle (Iα) in relation to the

horizontal [1 - 3]. As biomotor movements, they represent the transition of the body from the position of contact on a solid surface to an unsupported position, through its own muscular forces, whereby the synergistic muscular action of kinetic chains is manifested [4]. The Long Jump considered as track and field event in which athletes combine speed, strength, and agility in an attempt to leap as far as possible from a takeoff point. The jumper strives has to develop the most efficient technique possible while maximizing the performance which can be accomplished by balancing speed, power, strength, jumping ability and coordination. For long jump, explosive type strength is mainly manifested. Strength and the power both are an important component of long jump training, that can be increased by utilizing isotonic strength training like resistance raining or individuals own body weight, but these trainings help to develop strength but not speed [5]

According to authors [6] jumps improve the explosive strength of leg extensor muscles, running speed, joint mobility, coordination, and the ability to concentrate in a short period of time. In all jumps, an unwritten rule applies, that each subsequent phase in the technique of performance is conditioned by the previously performed phase, where any mistake has a significant impact on the correctness of movement in subsequent phases and the final result of competitors [7, 8]. Although it seems simple at first glance, long jump is motor and functionally complex discipline that requires the integration of most of the abilities of anthropological space. It is a discipline that combines speed and jump in technique, that is, the speed-strength properties of competitors. In the long jump, dynamic balance based on the compensatory movement (step technique) is of special importance, when, in relation to the center of gravity of the body, when moving one part of the body upwards, the other part moves downwards. Such movements in the flight phase also determine the jumping technique. In order to achieve top results, it is necessary for jumpers to have basic and special motor abilities (speed, strength, endurance, flexibility) as well as optimal height and body weight [1], which allows tall jumpers to start the flight phase from a much higher level when the center of gravity of the body moves in the air in accordance with the principles of projectile motion [9].

The influence of morphological and motor parameters on the results in jumps is not the same (long jump of 48%), and the remaining percentage falls on other parameters, primarily on technique [2]. The speed of the run, the intensity of the bounce impulse and

the swing of the free extremities are the components on which the length of the jump depends. The speed that the jumper achieves on the runway is not identical to the maximum sprint speed, due to the impossibility of a quality bounce. As a result, top jumpers make more use of their sprint speed (about 90%) than mid- and lower-level jumpers (85%). It is very significant, but the ability to transition speed to jump length is significant more. Also, the momentum of the front support is much higher than the moment of the rear support, so the speed of the jumper's center of gravity is significantly lower after the rebound than before the rebound [4]. The speed of running in the run for men is about 10.6m/s, for women 9.5m/s, and it is achieved with a run between 40 and 45 meters (for women a few meters shorter). When preparing for a bounce, the penultimate step is for a longer one (the center of mass of the body is lowered and placed behind the front leg), and the last step is 20 to 30 centimeters shorter than the previous one with raising the body's center of gravity [10]. Immediately before the jump, the jumper performs the so-called grouping (gathering) of body parts around the center of gravity so that they are on the trajectory of the ballistic curve, with the legs raised forward and up. The horizontal speed of the body's center of gravity itself depends on the speed of arrival on the board [11, 12]. When Powell (8.95m) broke the World record, he had a speed of 10.79 m/s when he arrived at the place of the jump. Every athlete is characterized by different mental and physical (morphological) characteristics, which distinguish them from other athletes. Their morphology is of a variable type, which means that there are both shorter and taller jumpers who possess extraordinary motor skills (speed, explosive power, coordination). Anthropological characteristics are largely genetically determined, primarily in relation to morphological dimensions. In addition to morphological features, motor abilities also play an important role, and together they form a universal profile of long jumpers. A characteristic of long jumpers is increased longitudinal and transverse skeletal and lighter body weight. An example can be given that in the ten best jumpers in the world the height is about 188cm, and in women from 172-180cm. However, the results of the research [13] of the finalists of the Olympic Games (Beijing, London, Rio) record an average lower body height and weight of jumpers (about 184cm-77kg for men and 173cm-60kg for women)

In general, jumpers are tall with relatively lighter body weight, with long legs, long and thin muscles. The muscle structure is dominated by white muscle fibers. According to the constitution, it is the leading

leptosomal type with the participation of athletics, which was confirmed by the research [14, 15]. In appearance and constitution, long jumpers are most similar to sprinters, because like sprinters, they must have high speed, explosive strength, leg and torso muscle strength, and running is one of the preconditions for performing a long jump. As an indicator of the physical condition of the jumper, the potential of speed strength appears, which is manifested in a fast and maximally strong bounce, when the pressure on the ground exceeds the weight of the athlete several times. This is where the synchronized action of the muscle kinetic chains, which extends from the feet to the muscles of the arms and shoulder girdle, comes to the fore. To perform complex actions, both when entering the bounce and during the jump itself, a high level of coordination of movements and a good condition of the vestibular apparatus is required. The need for larger amplitudes during swinging movements in jumping variants requires that jumpers achieve high mobility, especially the mobility of the spine (lumbar and thoracic part). There have also been attempts in the past, and also in the future, to continue to look for answers about the participation of certain anthropological characteristics in success in some jumping disciplines. If we look at the values and correlations with long jump, it can be concluded that explosive power, static power, speed of alternative movements as well as anaerobic potentials are important factors in the result performance. Morphological dimensions are not marked as relevant. Over the past century, it has become increasingly difficult to find athletes of the size and shape needed to compete successfully at the highest level. Not every physical characteristic can be expected to play a role in this selection process, but the two that are important and for which there are significant data sets are height and mass. A number of authors analyzed the morphological profile of athletes in the jumping disciplines of participants in the Olympic Games and World Championships in both competitions [14, 16] by analyzing differences in morphological space segments or kinematic parameters between finalists [17, 18] or result differences [19]. The results were mainly different depending on the sample, discipline, sex, morphological parameters, neuromuscular activities, other exogenous and endogenous factors.

There is a lack of research on the influence of height and body weight of the best jumpers (according to the achieved result) on the results of long jump. The main goal of the research is to determine the influence and possible connection of Body height (BH) and

Body weight (BW) with the best achieved results of (of all time) in Long jump males.

METHODOLOGY

The participants in study

The research included 21 competitors, top male long jumpers (Body Height = 184.19 ± 4.68cm; Body Weight = 78.86 ± 6.81kg). Their best results were analyzed. The criteria for inclusion in the study were that the jumper achieved the best personal result (Table 1) in the long jump (8.51m and more, concluding with a world record of 8.95m). The results are taken from the IAAF website http://athletedata.veebli.com/long-jump.html***

Table 1. Personal best result (All time) ***

Athlete	Long Jump PB (m)	Body height (cm)	Body weight (kg)
Mike Powell	8.95	188	77
Bob Beamon	8.90	191	70
Carl Lewis	8.87	188	81
Robert Emmiyan	8.86	178	69
Erick Walder	8.74	185	79
Larry Myricks	8.74	186	82
Dwight Philips	8.74	185	83
Irving Saladino	8.73	183	70
Ivan Pedroso	8.71	176	66
Sebastian Bayer	8.71	189	80
Louis Tsátoumas	8.66	186	77
Kareem Streete-Thompson	8.63	183	91
James Beckford	8.62	178	78
Yago Lamela	8.56	177	79
Aleksandr Menkov	8.56	178	74
Lutz Dombrowski	8.54	187	87
Mitchell Watt	8.54	184	83
Jaime Jefferson	8.53	187	75
Savanté Stringfellow	8.52	191	84
Roland Mc Ghee	8.51	180	79
Greg Rutherford	8.51	188	92

Design and statistical analysis

For the purposes of this research, defined body height and body weight as an independent variable while the results of Long jump were defined as dependent variables. First, the central and dispersion parameters (Mean, SD, Min, Max, Range, CI ±95.00%; CV%) were calculated for all variables, while the Pearson correlation coefficient was used to determine the relationship between body height and body weight and the results of Long jump. The level of acceptance of statistical significance was set to $p<0.05$. The obtained correlations are containsed in tables and graphs. In order to more accurately confirm the results defined by the research goal and to determine the influence of body height and body weight on the result performance, a univariate model of regression analysis was applied and the relevant coefficients were calculated. The statistical package STATISTICA, version 10.0 was used for data processing.

RESULTS

The results of the basic statistical parameters and simple regression analysis are contained in Table 1, 2 and Figures (1-4). The average distance Long jump result was 8.67 m in the range of 8.51m (McGhee & Rutherford) to a maximum of 8.95m-WR (Powell) in the range of 44cm. The analysis of the results (Table 1) showed that the largest number of jumpers achieved a result in the range of 8.50-8.60m (38.09%), from 8.60-8.70m (14.28%), 8.70 - 8.80m (28.57%) and 10% jumpers for results of (8.80-8.90m and 8.90-8.95m).

The jumpers had an average body height of 184,19cm, where as many as 14 (67%) competitors were 180-190cm tall, five (24.80%) ranged from 170-180cm and only two competitors over 190cm (10%), so the difference between the highest lowest jumper was 15cm. The average body weight was 78.86 kg, ten (47.61%) competitors had a body weight in the range of 80-90 kg, seven (33.33%) of 80-90 kg and two jumpers in the range of 60-70 kg 10%), or over 90kg (10%) where the difference between the lowest and highest body weight is 26kg. On the other hand, the analyzed degree of correlation and the influence of the body height of the jumper on the result success does not confirm the hypothesis of a statistically significant influence of this dimension on the result of the jump (Table 2, Figure 1, 3). A low and statistically insignificant correlation was recorded (Body height vs. Long Jump = 0.183), which was confirmed by the results of the regression function ($R^2 = 0.033$; $p>0.05$). However, body weight recorded a statistically significant, but inverse correlation with the jump result (Body weight vs. Long Jump = -0.442), which

confirms the result of the regression function (R^2 = 0.195; p<0.05) (Table 2; Figure 2, 4). The ICC between body height and body weight of jumpers defines a direct linear model but without statistical significance (Body height vs. Body weight = 0.383; p = 0.086) (Figure 5).

Table 2. Results of statistical analysis

	Mean±SD (Min.-Max.)	Range	CV%	Parameter	Pearson (r)	Sympe regression analysis		
						R^2	F	p<0.05
Long jump	8.67±0.13 (8.51-8.95)	0.44	1.60	**BH**	0.183	0.033	0.656	0.428
				BW	-0.442	0.195	4.603	0.045*

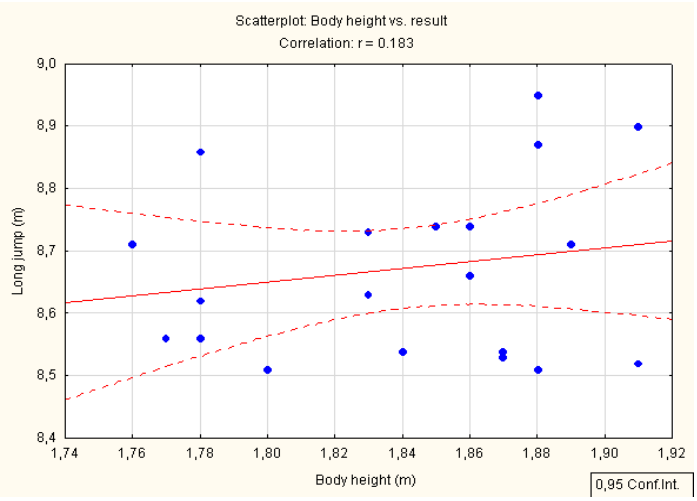


Figure 1. Pearson correlations (BH vs. Long jump)

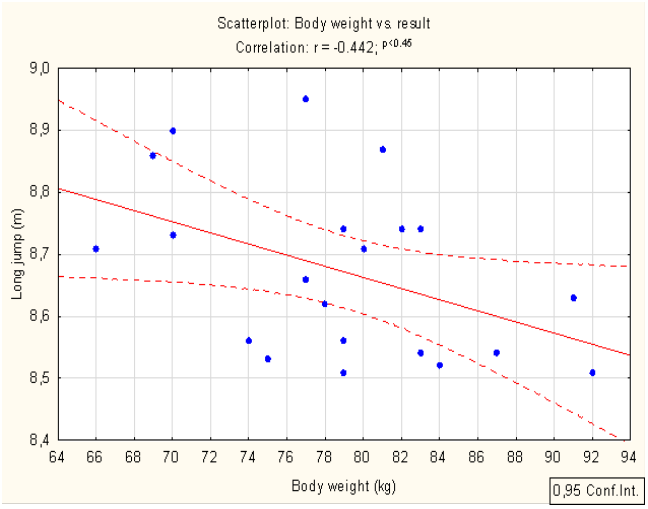
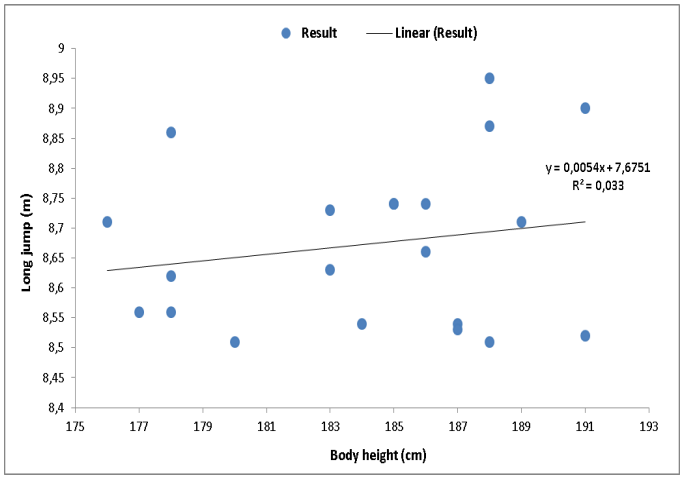


Figure 2. Pearson correlations (BW vs. Long jump)



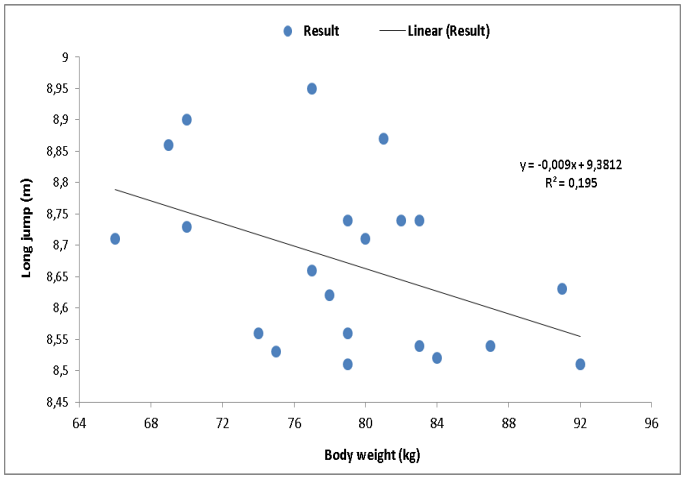


Figure 3. Symple regression analysis (BH vs. Long jump) **Figure 4.** Symple regression analysis (BW vs. Long jump)

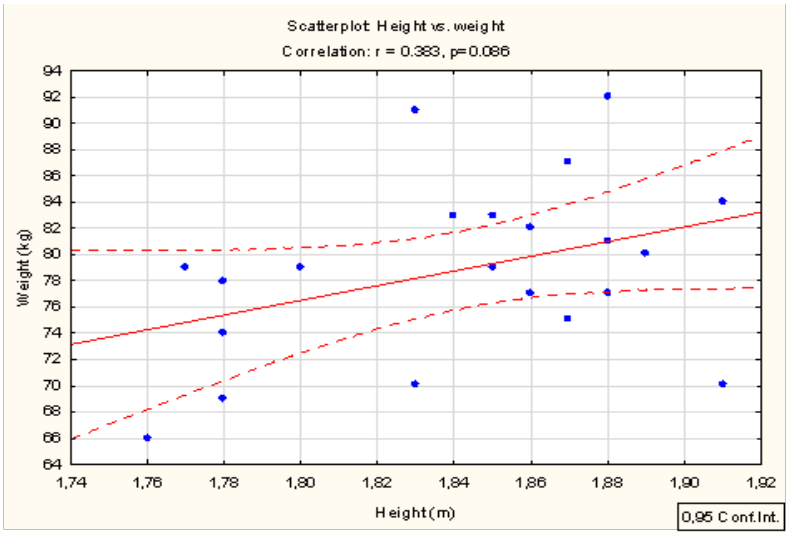


Figure 5. Pearson correlations jumpers (BH vs. BW)

DISCUSSION

The athletic discipline of long jump is a very complex activity that requires full integration of morphological, motor and functional parameters and each of these subsegments has a significant role in the overall jumping structure. This is especially evident when it comes to top athletes, where these segments are treated almost equally in the scoring success of male and female jumpers. However, in terms of structure (profile), it is the morphological space that often records significant differences within the same sexes of competitors in relation to motor and functional abilities. Physical resources that increase the speed of arrival on the board (about 11m/s) and the strength of the reflection at takeoff (more than 3.5m/s) are important determinants of the total distance

and jumping technique. In other words, speed or strength is an expression of structural physical resources or a set of physical characteristics, ie. height, weight, BMI and body composition [20].

The main goal of the research is to determine the influence and possible connection of Body height (BH) and Body weight (BW) with the best achieved results of (of all time) in Long jump men. From the results of the current study, it is evident that body weight had a statistically significant but inverse effect on the results of the long jump. According to [5, 21] body mass with excess fat has a negative effect on athletic disciplines, especially those in which the body leaves the ground as in jumps (it is evident in our study) or is in high acceleration above the ground (sprint, hurdles, long runs).

This inverse relationship between the body mass and the resulting success of the jumper leads to the conclusion that the body mass, although more defined by the muscle mass of the jumper, manifests as a disturbing factor of the achieved result. This is in favor of the fact that the long jump implies an integrated action of speed, explosive power, swing with free limbs and a correctly performed jumping technique in a given space and time, which is in accordance with the previous statements of the author. In every attempt to jump, it is necessary to achieve horizontal speed in order to neutralize the force of gravity, which negatively affects the angle of the jump, horizontal and vertical speed and the height of the body's center of gravity jumpers [22].

The average body weight of the jumpers of the current study (78.86 kg) has a negative effect on the performance. As an example, G. Rutherford has the highest mass (92kg) but also the weakest result (8.51m). However, if it is an active mass (muscle, bone) and not balast body mass (amount of adipose tissue) then this assumption is rejected. Less body mass is associated with muscle mass, and fat mass, which implies an inert substance, acts similarly to weight. Thus, physical characteristics, such as physique, refer not only to simple dimensional parameters but also to structural physical resources [23, 24]. The finalists of the Olympic Games in Rio 2016 (78.75kg) and London 2012 (77.25kg) have an almost identical body mass, while the smaller body mass was the smallest in Beijing (75.88kg).

Body height is an important parameter in the resulting success of the long jump due to the greater amplitude of movement, which, along with good technique and motor skills (speed, explosive power), is a prerequisite for a good jump which is consistent with the study [5].

The finalists in Beijing (184.50 cm) and Rio (184.50 cm) have an almost identical height,

while in London they were shorter (180.25 cm). Although not taken into account, the jumper's age, previous experience, mental stability can have a significant effect on the jump result in the current study. During the long jump, the synergistic muscular effect of the kinetic chains is manifested, where each subsequent phase is conditioned by the previous one, and each mistake significantly affects the final result [4-8]. As it is a discipline that combines speed and jump in technique, i.e. the speed-power characteristics of the competitor, dynamic balance based on compensatory movement (step technique) is of particular importance, when in relation to the center of gravity of the body, when moving one part of the body up wards, the second part moves down, which also projects the jump technique. In addition to the significant influence of the mentioned morphological and latent motor parameters on the results of jumps, a large percentage falls on the jump technique, which is in accordance with the earlier statements of the author [2]. When it comes to the ratio of height and body weight, it can be concluded that jumpers belong to the meso-ectomorphic or ecto-mesomorphic somatotype, where the height-weight ratio (BMI) plays a significant role.

In general, their anthropology is variable, we have shorter and taller jumpers, but with different motor and functional capacities, which can be seen in the results of this research.

CONCLUSION

The study aimed to determine the influence of body height and body weight of 21 elite male jumpers on the results in Long jump. Simple regression analysis and determined regression coefficients were applied. Pearson's intercorrelation coefficients were also calculated. Body height did not have a statistically significant effect on the results of long jumps, while body weight achieved a significant but inverse correlation with the result (Pearson $r = -0.442$; $R^2 = 0.195$; $p<0.045$). In long jump, much of the weight contains active muscle mass that integrates and generates the motor skills necessary for the success of the jump, primarily explosive strength and speed. However, a good jump technique is also necessary, but with optimal body weight, because any increase in weight has a negative inverse effect on the length of the jump.

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*** https://www.worldathletics.org/athletes