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Predictive value of kinematic indicators for shot put result and selection of novice athletes

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Abstract

Purpose: to determine the most significant kinematic indicators in the sports selection of beginner shot putters.
Material and Methods: This study was carried out on a sample of 9 students at the fourth stage of the competition in Division 1, which took place in the 2017/2018 academic year at the Faculty of Physical Education of Maysan University. The following kinematic (biomechanical) parameters were analyzed: the angle of release of the nucleus, the velocity of release, the height of the point of ejection of the nucleus and the speed of swing. The correlation coefficients were determined between the kinematic indicators and the result in the shot put, as well as the regression equation for the dependence of the result in the shot put on the knematic indicators. The data obtained in the study were presented in the form of the arithmetic mean, standard deviation, median, skewness coefficient, Pearson's correlation coefficient, analysis of variance and linear regression, which included the contribution coefficients of each analyzed indicator, standard error, reliability of the regression equation as a whole, and reliability of the coefficients contribution to the shot put result of each kinematic exponent.
Results. It has been shown that the swing speed has the greatest influence on the result in the shot put among beginner athletes. The swing speed, shot angle, shot speed and shot height have significant relationships with the shot put result. The multiple regression equation for the dependence of the shot put result on the swing speed, shot angle, shot height and shot point turned out to be reliable in general. However, only the swing speed has a reliable coefficient of the regression equation. The shot angle tends to be the determining factor in the shot put result. The release rate and the height of the release point have significant correlations with the shot put result, although in the regression equation they have unreliable indicators of influence on the shot put result.
Conclusions. When teaching beginner shot putters, the greatest attention should be paid to the pushing swing technique, namely the swing speed. The second most important indicator is the angle of the shot put, it is recommended to use the basic prediction equation, which determines the expected results in the selection of young athletes in shot put, with high reliability of the results obtained. These characteristics are recommended to be used for evaluating young athletes, as well as in the process of training and preparing athletes for competitions.
Key words: kinematic indicators, young athletes, shot put

Анотація

Хікмат Альматкорі, Ратко Павлович, Ірина Скрипченко, Боучареб Рафахія, Р. Рам Мохан Сінгх. Прогностична цінність кінематичних показників для результату в штовханні ядра і відбору атлетів-початківців

Мета: визначити найбільш значущі кінематичні показники в спортивному відборі штовхачів ядра, що починають.

Матеріал та методи: це дослідження було виконано на вибірці з 9 студентів на четвертому етапі змагань у Дивізіоні 1, які відбулися у 2017/2018 навчальному році на факультеті фізичного виховання Майсанського університету. Були проаналізовані такі кінематичні (біомеханічні) показники: кут випуску ядра, швидкість викиду, висота точки викиду ядра та швидкість замаху. Визначалися коефіцієнти кореляції між кінематичними показниками та результатом у штовханні ядра, а також рівняння регресії залежності результату у штовханні ядра від кнематичних показників. Дані, отримані в дослідженні, були представлені у вигляді середнього арифметичного, стандартного відхилення, медіани, коефіцієнта асиметрії, коефіцієнта кореляції Пірсона, дисперсійного аналізу та лінійної регресії, що включало коефіцієнти вкладу кожного аналізованого показника, стандартну помилку, достовірність рівняння регресії. вкладу у результат у штовханні ядра кожного кінематичного показника.

Результати. Показано, що на результат у штовханні ядра у атлетів-початківців найбільший вплив надає швидкість замаху. Швидкість замаху, кут випуску ядра, швидкість викиду та висота точки викиду ядра мають достовірні зв'язки з результатом у штовханні ядра. Рівняння множинної регресії залежності результату в штовханні ядра від швидкості замаху, кута випуску ядра, висоти викиду та точки викиду виявилося достовірним загалом. Однак достовірний коефіцієнт рівняння регресії має лише швидкість замаху. Кут випуску ядра має тенденцію як визначальний фактор результату в штовханні ядра. Швидкість викиду та висота точки викиду мають достовірні взаємозв'язки з результатом у штовханні ядра, хоча у рівнянні регресії мають недостовірні показники впливу на результат у штовханні ядра.

Висновки. Найбільшу увагу при навчанні штовхачів ядра слід приділяти техніці замаху при штовханні, а саме – швидкості замаху. Другим за значимістю показником є кут випуску ядра рекомендується використання базового рівняння прогнозування, яке визначає очікувані результати при відборі юних спортсменів у штовханні ядра, з високою надійністю отриманих результатів. Ці характеристики рекомендується використовувати в оцінки юних атлетів, а також у процесі тренування та підготовки спортсменів до змагань.

Ключові слова: кінематичні показники, юні спортсмени, штовхання ядра

Аннотация

Хикмат Альматкори, Ратко Павлович, Ирина Скрипченко, Боучареб Рафахия, Р. Рам Мохан Сингх. Прогностическая ценность кинематических показателей для результата в толкании ядра и отбора начинающих атлетов

Цель: определить наиболее значимые кинематические показатели в спортивном отборе начинающих толкателей ядра.

Материал и методы: это исследование было выполнено на выборке из 9 студентов на четвертом этапе соревнований в Дивизионе 1, которые состоялись в 2017/2018 учебном году на факультете физического воспитания Майсанского университета. Были проанализированы следующие кинематические (биомеханические) показатели: угол выпуска ядра, скорость выброса, высота точки выброса ядра и скорость замаха. Определялись коэффициенты корреляции между кинематическими показателями и результатом в толкании ядра, а также уравнение регрессии зависимости результата в толкании ядра от кнематических показателей. Данные, полученные в исследовании, были представлены в виде среднего арифметического, стандартного отклонения, медианы, коэффициента асимметрии, коэффициента корреляции Пирсона, дисперсионного анализа и линейной регрессии, которое включало коэффициенты вклада каждого анализируемого показателя, стандартную ошибку, достоверность уравнения регрессии в целом и достоверность коэффициентов вклада в результат в толкании ядра каждого кинематического показателя.

Результаты. Показано, что на результат в толкании ядра у начинающих атлетов наибольшее влияние оказывает скорость замаха. Скорость замаха, угол выпуска ядра, скорость выброса и высота точки выброса ядра имеют достоверные взаимосвязи с результатом в толкании ядра. Уравнение множественной регресии зависимости результата в толкании ядра от скорости замаха, угла выпуска ядра, высоты выброса и точки выброса оказалось достоверным в целом. Однако достоверный коэффициент уравнения регрессии имеет только скорость замаха. Угол выпуска ядра имеет тенденцию в качестве определяющего фактора результата в толкании ядра. Скорость выброса и высота точки выброса имеют достоверные взаимосвязи с результатом в толкании ядра, хотя в уравнении регрессии имеют недостоверные показатели влияния на результат в толкании ядра.

Выводы. Наибольшее внимание при обучении начинающих толкателей ядра следует уделять технике замаха при толкании, а именно – скорости замаха. Вторым по значимости показателем является угол выпуска ядра. Рекомендуется использование базового уравнения прогнозирования, которое определяет ожидаемые результаты при отборе юных спортсменов в толкании ядра, с высокой надежностью полученных результатов. Эти характеристики рекомендуется использовать для оценки юных атлетов, а также в процессе тренировки и подготовки спортсменов к соревнованиям.

Ключевые слова: кинематические показатели, юные спортсмены, толкание ядра

Introduction

The shot put is a field event in athletics and each of the events has a specific set of features including the characteristics of the implement used (size weight and aerodynamic qualities), space limitations, and technique requirements which influence the sequence of events and make them unique [1, 2]. The goal in the throwing events is to maximize the measured distance covered by the implement and this distance is determined by several parameters such as height, velocity, angle of release [3, 4], aerodynamic qualities, and environmental factors [5, 6], exploitation of the escape space when the equipment is thrown out and temporary foot position [7, 8]. The release height is a consequence of the athlete's length of the body, length of arm; body mass and it is a prerequisite for a candidate's selection for shot-putting. [1, 9]. The release angle depends on the release height and the release velocity [3,10]. The angle of the release is smaller, the higher the height and the speed of the throw [11]. It is relatively constant for an individual athlete and cannot be changed to improve the result. The release velocity is by far the most important of all the release parameters in determining the distance achieved because the distance is proportional to the square of the release velocity [6, 12].

The shot put competition is one of the athletics activities that is included in the international competitions like the Olympic Games, World Track & Field competitions, and continental Sports meet. Its skill performance is based on the same as other competitions due to mechanical conditions in its performance, despite the difference in the method or style of performing the movement before the final release of the shot. The analysis is the sorting and tabulation of the many data with its main elements, then logically treating them with a balance, with an appropriate standard and axis to shift from their precise quantitative formulas to others with meaningful explanations to solve the problem addressed by the researcher [13]. Biomechanical Knowledge is a "Must" for Coaching, and all movements of men and animals are determined by the laws of mechanics. It is the first task of science is to understand the movements of athletes; therefore it is an indispensable base for coaching. In the throwing events, the factors influencing the performance are governed by the physical laws of the flight phases of the implement and the biomechanical laws of the movement of the system, putter, and implement' before release [14]. Projectiles obey constant acceleration, making them easier to describe and understand (Galileo's equations). Three factors determine trajectory, including horizontal displacement, of a projectile speed of release, angle of release, the height of release. Positive height of release, the optimal angle should be slightly lower than 45°. Theoretically, the optimal angle is about 40-41°, skilled shot-putters use angles of 35-37° [3]. Shot-putting requires great explosive strength, together with the ability to perform precisely timed release of the (*add*) shot as far as possible, but competition regulations restrict the movements in a confined space. The athlete's objective is to project the technique that may be used. The shot must be thrown from the should using one hand and it must be held near to the chin throughout any preliminary movements (IAAF, 2000). In recent years many researchers have studied the techniques of shot put parameters and factors that are crucial for achieving top results, as well as those necessary for optimal performance.

Much research has been performed on the shot put, and several of these studies have examined the theory and practice of determining optimal release conditions, such as release speed, release angle, and release height [3, 10, 15]. Although these parameters directly determine the projected distance of the throw, they do not give any indication of the events leading up to the release. Consequently, they offer limited information to coaches seeking to improve the aspects of technique that will result in the best release parameters [16]. Some other studies have been descriptive and these have ranged from quantitative [17-20] to completely qualitative [21]. Although these studies do provide information about the kinematics of the performance, they too offered limited evidence as to which parameters were most influential on the performance. Also, the relative importance of each critical factor will vary for each athlete depending on such things as gender, anthropometry, strength parameters, throwing technique used (glide or spin), and individual stylistic elements [16].

In their research [22] defined some of the most important kinematic parameters of the rotational shot put technique. They used a 15-segment model of the thrower with 23 defined reference points The results showed that the top result of the throw depends on release velocity, the optimal angle of release, the relation between the rotational motion and acceleration of the final shot, and the angular velocity of the elbow and shoulder joints of the throwing arm. The authors [23] investigated the rotational model of the two techniques of elite shot putters with different anthropometric measures. Differences were found for: release velocity, release height, the maximum angular velocity in the elbow joint of the throwing

hand, the trajectory of the thrower and the shot, torsional rotation in the shoulder joint compared to the axis of the hip joint, maximum force focused on the ball, the kinetic energy independent of the sphere. Critical factors measured in this study included the speed of turning the right foot and the maximum force developed, the angle and height of release, and release velocity during the last phase. These factors are examined in connection with each athlete's throwing distance. A greater angle of a release causes a higher shot flight from the ground, but lower speed. During the flight phase, the shot acts as a projectile in free flight and its path can be calculated by using data on the conditions of release. Authors [3] aims to assess the accuracy of the method of calculating the angle of ejection for throwing shots. With this method the optimal angle of release, which produces the longest distance, is calculated by combining the equation for the range of missiles during free flight with a connection among the release velocity, release length, and angle of release. A crucial finding of the study of [24] is that the swing of the left hand must be performed with an amplitude that allows the pre-stretching of structures that are active in the pushing phase or with an amplitude that does not allow an increase in the shot movement radius. Release parameters are very important for successful performance and are mutually dependent. When the throw is made above the horizontal plane, the length of the throw depends on the height, angle, and velocity of the release [25]

Simple models of throwing were developed to explain the relationship between the release velocity, height, and angle related to the anthropometric measures and motor abilities of athletes [3]. A study by Young, & Li [16] is the first to examine critical parameters for success in elite women shot putters and indicates specific parameters that are important for achieving the highest standard in the event. The results of this study suggest that, among elite shot putters, bigger rear knee flexion at rear foot touch-down and release, increased release speed, a more neutral shoulder-hip angle at release and a larger horizontal release distance were the best predictors of the measured distance. Correlation analysis of this study [16] indicated that measured distance was positively correlated with release speed ($r = 0.97$, $p= 0.0003$) and shoulder-hip separation ($r = 0.72$, $p= 0.06$) and negatively correlated with release angle ($r= -0.74$, $p=0.056$), rear knee angle at rear foot touchdown ($r = -0.93$, $p=0.003$) and rear knee angle at release ($r = -0.76$, $p=0.047$). Greater knee flexion angle at both rear foot touch-down and release along with a neutral shoulder-hip angle at release was Identified as the most critical parameters for success among this sample of elite women shot putters. The research [10] between two throwers Multivariate regression analyses determined that achievable release speed decreases with increasing release angle at about 1.7 ($m \cdot s^{-1}$)/rad and decreases with increasing release height at about 0.8 (m/s)/m, with only small differences in sensitivities between the throwers. Horizontal release distance also decreases with increasing release angle at about 1.7 m/rad and increases with increasing release height at about 1.3 $m \cdot m^{-1}$, again with only small differences between the two throwers. In recent years there have been many researchers studying the techniques of shot put parameters and factors that are crucial for achieving top results, as well as those necessary for optimal performance.

Research [26] was conducted on the finalists of World Championship to determine the influence of anthropometric and kinematic parameters of the throw (release velocity, release height, release angle) on result successfulness in the shot put. A total of 32 competitors were included in the research, out of which 16 were male and 16 were female finalists. Obtained results were processed by multiple regression analysis which confirmed a statistically significant influence of predictors on the result of male shot put finalists ($R=0,793^{**}$, $R^2=0,629$) and female finalists ($R=0,806^{**}$; $R^2=0,650$). The obtained results of regression analysis confirmed that the speed of the throw-out (Vo) was a leading parameter in the successfulness of the finalists' result (Beta(f)=0,691; Beta(m)=0,528] and an inverse relationship with the angle of the throw-out, which can be confirmed by previous research on this subject. Interestingly, the angle of the throw-out in female shot-putters was not defined as a factor of the impact on regression function, while the height of the throw-out recorded slight inversion in comparison to the throw-out angle and the speed as a consequence of the force of gravity. The aim of this study [27] was to determine differences in the parameters of the release of top Serbian athletes. The throwing technique was taken at the Serbian Cup 2011 for the competitors who achieved the best results. The values of the variables were determined by using software for 2D kinematic analysis, "Human", version 6.0 HMA Technology Inc. 2005, United States of America (Human). The first-place contestant scored a higher release speed of 13 $m \cdot s^{-1}$ (13.79 $m \cdot s^{-1}$), while the speed of the second and the third was much lower (11.9 $m \cdot s^{-1}$ and 11.68 $m \cdot s^{-1}$), The maximum height of release was determined for the second-placed competitor (2.22m), then for the first-placed (2.07m) and the third-placed competitor (2.05m), The angle of release for the top-placed competitor was 40.4˚, 42.8˚ for second-placed and 41˚ for the third-placed. In the case of the top-ranked

competitor and the third, there is the possibility of increasing the horizontal length of the shot put.

The organization of kinematics and movement within each stage is jointly accredited within and across each stage, so coaches should consider the athlete's biomechanics [28]. The low local levels in (Iraq) in recent years compared to the progress of international levels may be due to the weak codification of the training programs applied, especially those that depend on building their exercises on the mechanical conditions accompanying the kinetic technical performance of the thrower, including the peripheral velocity of the joint point of the driving arm of the group and the basic kinematic variables related to the moment The shot is released from the player's hand, through which the forward horizontal distance (the archer's Shot put result) is determined [29]. And through a simple comparison of the levels recorded in Olympia, continental and worldwide, which exceeded meters in most international tournaments for the first-placed holders in each championship, as well as the (Iraqi) record recorded more than twenty years ago, of (18.36 m) for the hero Khaled Muhammad Wajih, with the numbers recorded in the last two decades and not exceeding meters for the Iraqi champions in local and international championships, the Iraqi digital low level is undoubtedly evident, that the great decline may be due to the weakness of training programs, which may be limited only by relying on the development of some physical abilities and old methods of developing performance skills The technical and also the qualitative analysis by the coach, which is not commensurate with the size of the great scientific progress that the modern training process has reached, which depends on building its exercises on the foundations and values of biomechanical kinematic analysis programs, and also that the proper and early selection of novice athletes may predict the project of an upcoming champion, and this is what It is produced by the results of scientific research, especially those that depend on the values of the special mechanical variables in the final payment phase of the batch, in addition to the physical capabilities and specifications that it has Suitable [29, 30, 31]. Due to the importance of this competition internationally and its place among other games, especially track and field competitions, the researchers decided to conduct this study, to avoid some of the weaknesses of novice athletes in the future and to enhance and develop the positive points, and thus contribute to the development and improvement of the Shot put result.

Purpose: to determine the most significant kinematic indicators in the sports selection of beginner shot putters.

Materials and methods

Participants

The researchers used the descriptive approach due to its relevance to the nature of the research and chose eight (9) students from the fourth stage of Division (1) for the academic year 2017/2018 at the Faculty of Physical Education, University of Maysan, Iraq.

Procedure

The sample was chosen in the intended method, and they are the best shot put result among their peers, and Table (1) shows the Specification sample.

Table 1

Shows the sample specifications and their homogeneity

Basic variables	Arithmetic mean	Standard deviation	Median	Coefficient of torsion
Age (years)	21.78	0.88	21	1.14
Body Height (cm)	169.56	0.87	170	0.96
Bodyweight (kg)	74.11	1.99	73	0.83
Shot put result (M)	11.947	0.172	11.8	1.6

It is evident from Table 1. that the torsion coefficient for all members of the research sample is homogeneous, because the value of the torsion coefficient in all variables that may affect the results of the research is within (± 3), which indicates its homogeneity.

Statistical Analysis

The data obtained in the study were given as arithmetic mean, standard deviation, median, skew coefficient, Pearson correlation coefficient, analysis of variance and linear regression, constant term, standard error.

Results

To obtain the correlation coefficients between the research variables, the researcher used the simple correlation (Pearson) as a statistical method to achieve this purpose. Table (2) shows the simple correlation coefficients and their contribution ratios between the variables included in the regression of the dependent variable (the numerical level) with the independent variables (kinematics).

Table 2

Mean, standard deviations, correlation coefficient, contribution rate, and the level of significance between the shot put result and some kinematic variables

The kinematics Variables	Mean±Std.Dev.	Simple correlation	Contribution rate	Significance ratio (p)
Angle of Release (degree)	35.444±1,130	0.876	0.767	0.000
Release velocity($m \cdot s^{-1}$)	11.947±0,172	0.913	0.834	0.000
The height of the release point (M)	1.936±0,628	0.923	0.852	0.000
Swing speed ($m \cdot s^{-1}$)	9.849±0,628	0.942	0.887	0.000

The correlation of the Shot put result with the Angle of Release variable (0.876) and the contribution percentage (0.767) and the level of significance (0.000). The correlation of the Shot put result with the Release velocity variable was (0.913) and the contribution percentage (0.834) and the level of significance (0.000), while the correlation of the Shot put result wi variable reached. The height of the Release point was (0.923) and the contribution percentage (0.852) and the level of significance (0.000). The correlation of the Shot put result with the variable peripheral velocity reached (0.942), the contribution percentage (0.887), and the level of significance (0.000).

Table 3

The correlation coefficient, the multiple contribution ratio, and the standard error of the estimation between the shot put result and some kinematic variables

Model	Multiple correlations	Contribution rate	Std error of the estimate
1	0.963	0.927	0.065

Through our observation of Table 3, it becomes clear to us the value of the multiple correlations, as it reached (0.963) and the contribution rate (0.927), and with a standard error rate of (0.065) with the values of the numerical level, and to identify the regression coefficient of the contribution of some independent variables (kinematic) to predict the measurement of (The numerical level) as a dependent variable, the researchers used the test (analysis of variance) as shown in Table (4).

Table 4

Analysis of Variance of the multiple regression to check the quality of compatibility of the multiple linear regression model of the Shot put result and some of the kinematic variables

Model		Sum of squares	Degree of freedom	Average of squares	F	Significance ratio (p)
Shot put result	Regression	0.220	4	0.055	13.75	0.02
	Residual	0.017	8	0.004		
	Total	0.237				

By observing Table 4. it becomes clear to us that the independent variables are suitable for predicting the measurement of the shot put result of players (11.947) through the significance of the value of (F), as it reached (13.75) with an error rate (0.02), and in order to arrive at the equation of the multiple regression lines, the researcher used the test (T-test) as shown in Table 5.

Table 5

The values of the constant limit and the slope (effect) between the numerical plane and some kinematic variables

Model		Unstandardized Coefficients		t	Significance ratio (p)
		B	Standard error		
1	Constant	6.287	2.908	2.162	0.097
Shot put result	Angle of Release (degree)	0.024	0.093	-0.261	0.807
	Release velocity ($m \cdot s^{-1}$)	0.113	0.207	0.549	0.612
	The height of the release point (M)	2.236	2.148	1.041	0.357
	Peripheral velocity ($m \cdot s^{-1}$)	2.341	0.326	2.675	0.046

It can be seen from Table 5. that the variable (height of the starting point) is the first contributing variable, the variable (velocity of departure) the independent variable, the second contributing variable, the variable (peripheral velocity), the independent variable, the third contributing variable, and the variable (the angle of release) of the independent variable, the fourth contributing variable. The predictive regression equation for the numeric plane in terms of the influencing estimates (angle of departure, cruising speed, height of the starting point, and peripheral velocity). Therefore, the predictive equation can be derived using the multiple regression equation as follows:

The predictive value of the numeric plane = 6.287 - (0.024 × the arithmetic mean of the path angle variable) + (0.113 × the arithmetic mean of the path velocity variable) + (2.236 × the arithmetic mean of the starting point height variable) + (0.108 × the arithmetic mean of the path velocity variable). Predictive value of numeric level = 11.952.

This requires the player to be strong and flexible limbs because it contributes significantly with the rest of the physical and mechanical variables to increase the shot speed from the putter's hand to the moment of the final push and through the occurrence of a reverse reaction to the movement of the hip at the moment of stopping due to the large resistance arm represented by the limited front movement [30]. The angle of release is an influential factor in achieving the longest horizontal distance forward that the shot puts, especially if the other basic mechanical conditions in the throwing process are met with it, which is the launch speed that has to do with the horizontal velocity of the player, which he acquires through the kinetic transfer of his center of gravity within the throwing circle towards the throwing sector, and with height The Release point [29]. It is worth noting that some basic mechanical aspects must be studied in motion analysis and, optimal release conditions producing a maximum range for a particular athlete can be determined [10].

Discussion

The importance of sportspersons operation status as a leading factor in high sports performance is doubtless. The offered study includes assessment and correction of the sportsperson's operation status during the competitions, which was based on the multi-factorial express- diagnosis of the functional condition, variation pulsometry, and body impedance analysis.

In the event like shot put, where even the slightest change in the body position right from the starting point to the release of the shot could make a significant difference to performance which in turn can impact a win or a loss. Further, shot put can be said as an event of closed technique where the athlete is clearly and fully aware of what he or she is going to or expected to do. Hence, the athlete can train accordingly and prepare well if he or she can automatize the movement pattern that is best suitable for their body. The athlete will be able to mechanize the technique to such an extent every time the athlete prepares to make a put, the body is completely aware of its position and movement pattern. It must be noted that once the shot is released, there is nothing in the power of the athlete to control it. Hence, the more accurate and perfect the technique and the movement pattern is leading up to the point of release, the more reliable and consistent the athlete's performance will become. This will certainly enable the athlete to plan better, train better, perform better and progress in the best manner possible. This is ultimately the goal of any competitive shot putter,

According to the received data, the multiple linear regression equation was calculated as well as the most significant characteristics of the body impedance analysis were detected. It is mentioned that the analysis is sorting and categorizing the many

data with its main elements, then processing them logically with a balance with an appropriate standard and pivot to switch from their precise quantitative formulas to others of useful meanings to solve the problem addressed by the researcher [13].

As far as the authors know, this is the first study, based on the factor, correlation, and regression analysis aimed at completing the model of highly skilled throwers shot put competition operation status model. Authors [29] studied the body mass indicators of athletes and determined their role in assessing the preparedness of athletes. Authors [32] conducted a systematic review and identified prospects for the future in the use of bioimpedance analysis in sport and exercise. Authors [33] in his studies established a specific profile of an athlete according to the characteristics of body composition: Fat free mass, total body water and fat mass which completely coincides with our studies

Conclusion

It has been shown that the swing speed has the greatest influence on the result in the shot put among beginner athletes. The swing speed, shot angle, shot speed and shot height have significant relationships with the shot put result. The multiple regression equation for the dependence of the shot put result on the swing speed, shot angle, shot height and shot point turned out to be reliable in general. However, only the swing speed has a reliable coefficient of the regression equation. The shot angle tends to be the determining factor in the shot put result. The release rate and the height of the release point have significant correlations with the shot put result, although in the regression equation they have unreliable indicators of influence on the shot put result.

When teaching beginner shot putters, the greatest attention should be paid to the pushing swing technique, namely the swing speed. The second most important indicator is the kernel release angle.

Recommendations

1 – It is important to adopt mechanical foundations in building skill exercises when teaching and training beginners to put the shot.

2 – Predictive equations based on mechanical foundations at the moment of shot put into place for members of the research sample can be used in the process of selecting junior athletes in the shot put competition.

3 – Conducting similar studies on other track and field competitions

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Conflicts of interest

Authors have no conflict of interest to declare.

References

1. Pavlović R. *Athletics 2 - textbook*, Niš. Association of writers Branko Miljkovic; 2016. (In Serbian)
2. Kapur A, & Devi-Khomdramm S. Release characteristics of shotput: A kinematic approach. *International Journal of Advanced Research and Development*. 2017; 2 (4): 82-84.
3. Linthorne NP. Optimum release angle in the shot put. *Journal of Sports Sciences*. 2001; 19 (5): 359–372. DOI: 10.1080/02640410152006135.
4. Lenz A, & Rappl, F. The optimal angle of Release in Shot Put." Published in arXiv preprint arXiv: 2010; 1007.3689, 1-16
5. Stanković D, & Raković A. *Athletics-textbook*.University in Niš: Faculty of Sport and Physical Education, 2010. (In Serbian)
6. Mihajlović I. *Athletics-textbook.* Novi Sad: Faculty of Physical education and Sport; 2010. (In Serbian)
7. Bowerman WJ, Freeman WH, & Vern Gambetta TAC. *Athletics.* Zagreb-Gopal, 1998. (In Croatian).
8. Smajlović N. Athletics-textbook. Sarajevo: Faculty of Physical education and sport, 2010. (In Serbian)
9. Lanka J. Shot putting. In Zatsiorsky VM (Ed.), *Biomechanics in Sport, Performance Enhancement and Injury Prevention;* Oxford: Blackwell Science, 435-457, 2000.
10. Hubbard M, de Mestre N, Scott J. Dependence of release variables in the shot put. *Journal of Biomechanics.* 2001*;* *(*34): 449-456. doi:10.1016/S0021-9290(00)00228-1.
11. Čoh M. *Athletics - technique of methodology of some athletic disciplines*. University in Ljubljana, Institut for sport. 2002 (In Bošnjak G. *Athletics-textbook, philosophical-scientific basics and application in practice*. Banja Luka: Faculty of Physical education and Sport; 2011 (In Serbian)
12. Moor N. *How to Do Research,* (London, The Library Association), 1999, p.155.

13. Sugumar CA. Biomechanical Analysis of The Shot Put Performance. *Physical Education.* 2014; 3 (5): 118-119.
14. Degot M, Blache Y, Vigne G, Franger G, Neyton L, Rogowski I. Intra- and intersession reliability and agreement of the Unilateral Seated Shot-Put Test outcome measures in healthy male athletes. *Bmc Sports Science Medicine and Rehabilitation.* 2021;13(1).
15. Young M., & Li L. Determination of Critical Parameters among Elite Female Shot Putters. *Sports Biomechanics*. 2005; 4 (2): 131–148. DOI: 10.1080/14763140508522859
16. Mc Coy R W. Biomechanical Analysis of the Men's and Women's Shot Put. (Unpublished technical report from the 1989 TAC Championships.) Williamsburg: The College of William and Mary, 1990.
17. Stepánek J. Findings of the IAAF biomechanical research concerning shot put. In Brüggemann, G-P., Ruhl and J. K. (eds.), *Techniques in Athletics* (pp. 625–628). Cologne: Deutsche Sporthochschule, 1990
18. Yadav SA, Nikam PP. Prevalence of multidirectional shoulder instability in shot put throwers. *International Journal of Physiotherapy*. 2020;7(1):54-8.
19. Watson MD, Davies GJ, Riemann BL. Relationship Between Seated Single-Arm Shot Put and Isokinetic Shoulder Flexion and Elbow Extension Strength. *Journal of Sport Rehabilitation*. 2021;30(3):521-4.
20. Traas J, Hamant O. Yves Couder: Putting mechanics back into the shoot apical meristem. *Comptes Rendus Mecanique*. 2020;348(6-7):679-84.
21. Thuc DC. Effect of Mastery Cooperative Studying and Individual Inquiry on Attaining the Technical Aspects of the Stages of Shot Put and Digital Achievement Using the Linear Procedure Among Vietnam University Students. *Bioscience Biotechnology Research Communications.* 2019;12(4):912-20.
22. Vasilyev N, Gromyko V, Anosov S, editors. Non-alternative Artificial and Natural Intelligences Partnership for Put up Shoot in and Return to Rational Co-evolution with Noosphere. *13th International Conference on Agents and Artificial Intelligence (ICAART*); 2021 Feb 04-06; Electr Network2021.
23. Thaqi A, Berisha M, Asllani I. The effect of plyometric training on performance levels of the shot put technique and its related motor abilities. Pedagogy of Physical Culture and Sports. 2021;25(3):144-51.
24. Riemann BL, Davies GJ. Association Between the Seated Single-Arm Shot-Put Test With isokinetic Pushing Force. Journal of Sport Rehabilitation. 2020;29(5):689-92.
25. Pavlović, R., Vrcić, M. Influence Of Anthropometric And Kinematic Parameters On Result Successfulness Of Shot Put Finalists (Wc Berlin 2009-Daegu 2011). *Journal of Physical Education Research*, JOPER. 2020; 6 (1):29-37.
26. Riemann BL, Collins B, Rowe J, Davies GJ. Limb Dominance Effects On Seated Single Arm Shot Put Limb Symmetry Indices Following Shoulder Rehabilitation. *Medicine and Science in Sports and Exercise.* 2021;53(8):380-.
27. Schofield M, Cronin JB, Macadam P, & Hébert-Losier K. Rotational shot put: a phase analysis of current kinematic knowledge. *Sports Biomechanics*. 2019; (8): 1-19. https://doi.org/10.1080/14763141.2019.1636130
28. Almadhkhori HA. *Biomechanics and kinetic analysis in mathematical skills*, Moonlight Publishing and Distribution, Baghdad, Iraq, House of Books and Documentation No. 1441 for the year 2020, ISBN: 9789922919232.
29. Pinheiro JS, Monteiro OLS, Pinheiro CAB, Penha LMB, Almeida MQG, Bassi-Dibai D, et al. Seated Single-Arm Shot-Put Test to Measure the Functional Performance of the Upper Limbs in Exercise Practitioners With Chronic Shoulder Pain: A Reliability Study. *Journal of Chiropractic Medicine*. 2020;19(3):153-8.
30. Gutiérrez R. Gutierrez R. *Why we need to rehumanize mathematics.* Reston, VA: National Council of Teachers of Mathematics. 2018.
31. Malá L, Zahálka F, Maly T. Bioimpedance for Analysis of Body Composition in Sports. In book: *Bioimpedance in Biomedical Applications and Research*, 2018. DOI: 10.1007/978-3-319-74388-2_12
32. Campa F, Toselli S. Bioimpedance Vector Analysis of Élite, Sub-Élite and Low-Level Male Volleyball Players *International journal of sports physiology and performance*. 2018; 13(9):1-13.DOI: 10.1123/ijspp.2018-0039
33. Petelewicz P, Orlinski PM, Schiavon M, Mundo-Ocampo M, Becker JO, Baird JH. Fluopyram Controls Shoot-galling Caused by Pacific Shoot-gall Nematode and Improves Turf Quality in Annual Bluegrass Putting Greens. *Horttechnology.* 2020;30(6):709-18.

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