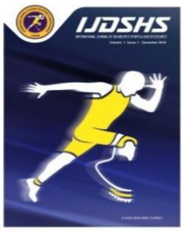

International Journal of
Disabilities Sports and Health Sciences

e-ISSN: 2645-9094

RESEARCH ARTICLE

The Contribution Percentage of Some Biomechanical Variables to the First 10 Meters in the Achievement of Men's 100-Meter Sprint

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Abstract
The study aimed to identify the contribution percentage of certain variables to the technical performance of the 100-meter sprint. To achieve this goal, the researcher filmed the runners during the competition period using two motion analysis cameras operating at a speed of 120 frames per second. The research population comprised (45) attempts taken from 9 runners, with (5) attempts for each runner who participated in the second round of the Iraq Clubs Championship in Al-Jadriya on 3/3/2023. The researcher hypothesized that there is variability in the contribution percentages of the biomechanical variables to performance. The researcher identified 12 biomechanical variables after reviewing numerous scientific sources and considering the opinions of experts and specialists in this field. Relevant specific tests were conducted, and after the motion analysis, the researcher used correlational relationships to determine which variables contributed most significantly to the performance. Several conclusions were reached, including that the variables (acceleration in the first 10 meters, average speed for 10 meters, and time for the first 10 meters) achieved the highest correlation with performance, registering values of -0.698, -0.626, and -0.623, respectively. The acceleration for the first 10 meters is identified as the most influential independent biomechanical variable in performance, with a contribution percentage of 0.994. Increasing variables such as contact time, step frequency, and reaction time enhance performance. The researcher suggests prioritizing training to develop these biomechanical variables with the highest impact on performance and incorporating study findings into training programs to address weaknesses in both physical and technical aspects.

Keywords
Contribution Percentage, Biomechanical Variables, Achievement in 100-Meter Sprint, Reaction Time

INTRODUCTION

The biomechanical analysis is an effective method for identifying numerous and varied facts about the intricate motion paths of body parts in a scientific manner, as it relies on the physical and anatomical laws governing the human body (Challoub & Sabeeh, 2021). The 100-meter sprint event is one of the activities that relies on numerous variables. If these are studied through biomechanical analysis, we can understand the impact of these variables and their extent of contribution to achievement (Kareem & Abdul-Mohsen, 2023). The technical performance of the 100-meter sprint depends on specific biomechanical variables in a certain sequence. By isolating the variables that contribute most significantly to achievement, we can accurately direct efforts to achieve optimal performance (Hasan & Gambash, 2023).

The significance of this research is highlighted by the ongoing interest in athletic achievements and the continuous efforts to enhance them. Additionally, the importance of biomechanical analysis lies in uncovering the strengths and weaknesses of athletes. Furthermore,

Received: 18 January 2024 ; **Revised** ; 06 March 2024 ; **Accepted:** 07 April 2024; **Published:** 20 May 2024

How to cite this article: Hussein, E.S. (2024). The Contribution Percentage of Some Biomechanical Variables to the First 10 Meters in the Achievement of Men's 100-Meter Sprint. *Int J Disabil Sports Health Sci*;7(Special Issue 2):206-216 https://doi.org/10.33438/ijdshs.1422013

this research emphasizes the importance of providing mechanical information regarding the technical performance, particularly for the first 10 meters of the race.

The cognitive problem of this study revolved around whether it is possible to determine the numerical values for the starting and launching phase, as well as the contribution percentages of the first 10 meters in the 100-meter sprint event for men. Additionally, the study aimed to understand the extent of their impact on the final achievement. This prompted the researcher to delve into biomechanics and kinematic analysis of performance variables related to this distance, as well as their contribution to the achievement of athletes participating in the second round of the 2023 Iraq Championship.

The research aimed to identify the values of key biomechanical variables related to the technical performance of the first 10 meters in the 100-meter sprint event and to determine the contribution percentage of these variables to the final achievement.

The researcher assumed that there is variation in the contribution percentages of biomechanical variables to the achievement in the 100-meter sprint event. As for the research domains, the human domain represents the 100-meter sprint athletes participating in the second round of the Iraq Championship in 2023. The spatial domain was the Najaf International Stadium for Athletics. As for the temporal domain, it spanned from 15/02/2023 to 15/04/2023.

MATERIALS AND METHODS

Participants

The researcher obtained ethical approval from the Scientific Department of the University, as well as voluntary participation consent from elite runners registered with the Central Iraqi Federation for Athletics. This article's necessary ethics committee permissions were obtained with University of Baghdad College of Physical Education and Sports Sciences for Woman Ethics Committee Commission Date: 17.01.2024 Issue/Decision No: 2024/14. Participant provided informed consent, with the volunteer form covering research details, risks, benefits, confidentiality, and participant rights. The research strictly adhered to the ethical principles of the Declaration of Helsinki, prioritizing participant's rights and well-being in design, procedures, and confidentiality measures..

Procedures

The researcher employed a descriptive method with correlational relations and contribution percentages, as it suited the nature of the problem. The research population consisted of observations taken from the athletes participating in the second round of the Iraq Clubs Championship in Baghdad, totalling nine athletes. Each athlete competed in five races during the competition period, with training at the end of each week. The sample comprised these repetitions, amounting to 45 observations. The researcher also selected certain variables to ensure homogeneity in these characteristics, as shown in Table 1.

Table 1. The players' specifications and their homogeneity

Statistical Parameters / Variables	Measurement Unit	Arithmetic Mean	Median	Standard Deviation	Skewness Coefficient
Height	Meter	1.75	1.745	2.48	0.812
Mass	Kilogram	78.33	78.5	2.78	-0.583
Chronological Age	Year	26.33	26.5	2.24	0.412
Training Age	Year	8.22	8	2.79	-0.211

Table 1. shows that the values of the skewness coefficient range between (±1), indicating the homogeneity of the research sample individuals in these variables, i.e., the normality of their distribution.

Data Collection Methods

Used Equipment

Observation, which is one of the most important tools used in scientific research. Personal interviews with experts and coaches. Data registration form to record the probability values.

Used Equipment. A Korean-made analysis camera, CASIO Exilic EX-FH12.5, can capture at a speed of 120 fra-mes per second, with a total of (2) cameras used for analyzing and calculating the study variab-les. A 1-meter ruler for calibration with the motion analysis cameras. An electronic medical scale for measuring the runners' mass to conduct homogenization. A metric measuring tape for measuring the lengths of the runners to conduct homogeniza-tion. A Swedish-made starting block for a seated starting position. A Chinese-made race starting pistol, producing a sound signal, used for signalling the runners to start. Three stopwatches to record the arithmetic mean for each participant. The motion analysis software (Kenova) to analyze the variables specific to the study.

Biomechanical Variables

After reviewing specialized sources, the researcher selected the following variables as shown in Table 2.

Table 2. Kinematic Variables

Variables	Measurement Unit
Achievement	Second
Reaction Time	Second
Time for the First 10 Meters	Second
Average Speed	m/s
Acceleration in the First 10 Meters	m/s^2
Number of Steps	Count
Step Frequency	Step/s
Step Length	Meter
Foot Contact Time	Second
Flight Time	Second
Peripheral Speed of the Foot	m/s
Peripheral Speed of the Arm	m/s

Exploratory Experiment

The exploratory experiment was conducted on 15/02/2023, using two cameras. It involved filming a single runner, who was not part of the research sample, at Al-Najaf International Stadium for Athletics. The purpose of this was to determine the camera placements, distances, required equipment, and potential obstacles that may arise during the main experiment.

The Main Experiment

The main experiment was conducted from 3/02/2023 to 2/03/2023, spanning an entire month during the competition phase. This extended duration was chosen as filming took place every Thursday at the end of the training week to ensure testing at 100% intensity, providing real numerical values closely resembling race conditions. Two analysis cameras of the type (CASIO FH13.5) were utilized, with a speed of 120 frames per second and a height of 1.2 meters. The first camera was positioned perpendicular to the first five meters from the starting point, while the second camera was placed at the second five meters from the starting point to cover the entire ten meters with high precision, as shown in Fig 1. The analysis was conducted using the (Kenova) software to calculate the variables.

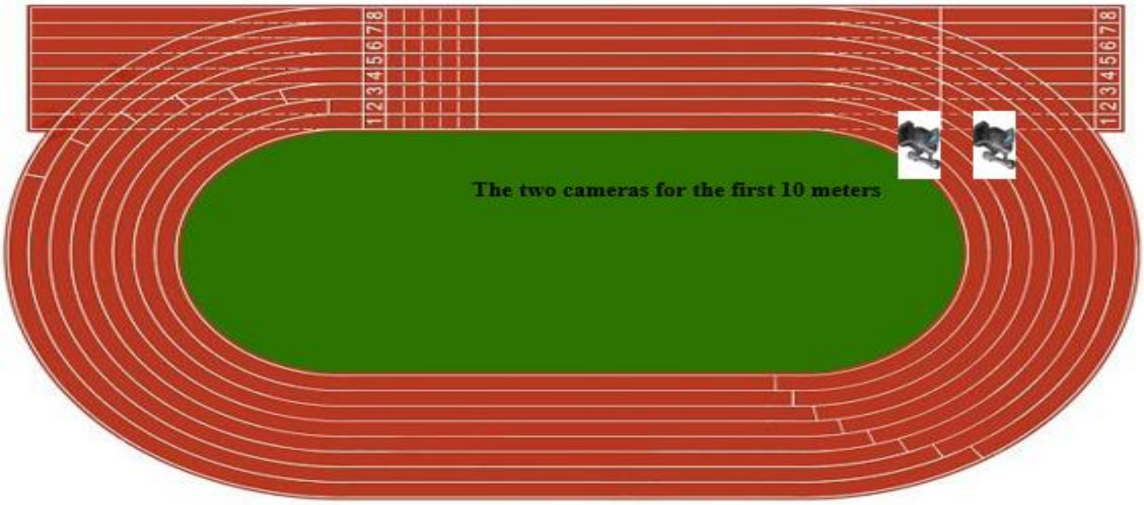

Figure 1. The method of filming the performance test for 100-meter sprinters

Calculation of Research Variables

The analysis begins by converting the film format from digital audio tape (DAT) to moving picture experts group (MPEG) for easy handling.

The researcher used the (Kenova 9.5) software to calculate the studied variables.

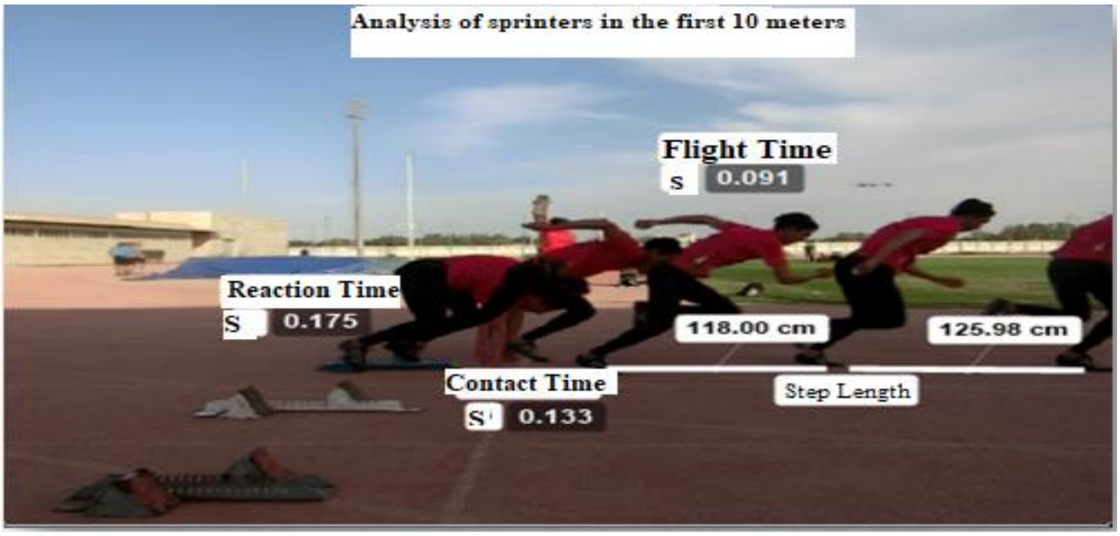

Figure 2. The calculation of variables related to the first 10 meters of the race

This software can accurately calculate real-time data once it is provided with information about the camera's speed and can track specific points to calculate foot and arm peripheral speed and measure step length, as shown in Fig 2.

Statistical Analysis

A statistical program was used in the statistical analysis of the data obtained. Arithmetic mean, standard deviation, frequency, minimum and maximum values were used in statistical representations of the data. In the normality testing of the data, kurtosis and skewness values of ±1.5 were taken into consideration. Simple Correlation, Multiple Correlation, Coefficient of Determination (Contribution Per-centage) R^2 in data analysis has been used.

RESULTS

Presentation of the results of biomechanical variab-les' descriptive values for the 100-meter sprint and their analysis and discussion.

Table 3. The descriptive values of biomechanical variables for the 100-meter sprint event

Variables	Arithmetic Mean	Standard Deviation
Achievement	10.861	0.304
Reaction Time	0.170	0.001
Time for the First 10 Meters	1.875	0.072
Average Speed	5.331	0.212
Acceleration in the First 10 Meters	3.211	0.283
Number of Steps	7.838	0.216
Step Frequency	4.177	0.213
Step Length	1.276	0.036
Foot Contact Time	0.134	0.002
Flight Time	0.806	0.024
Peripheral Speed of the Foot	4.699	0.105
Peripheral Speed of the Arm	2.284	0.338

The researcher resorted to calculating the arithmetic mean to describe the values with their central tendencies and express them as a single value. The standard deviation was also calculated to determine the accuracy of the mean in expressing the values of the variables. The arithmetic mean and standard deviation for the achievement were (10.861) and (0.304), respectively. The researcher considers this time to be relatively weak compared to the Iraqi national record of 10.32 seconds and significantly distant from Arab, Asian, and international standards. Additionally, the arithmetic mean and standard deviation for reaction time were (0.170) and (0.001). The researcher considers the reaction time to be somewhat good and comparable to the times of most runners at the international level. The mean and standard deviation for the time of the first 10 meters were (1.875) and (0.072). The researcher believes that the total time to cover the first 10 meters falls within the normal range. Additionally, the arithmetic mean and standard deviation for the average speed were (5.331) and (0.212), which is also considered within normal limits. Furthermore, the arithmetic mean and standard deviation for the acceleration in the first 10 meters were (3.211) and (0.283). The researcher believes that the acceleration rate did not ideally meet expectations. The arithmetic mean and standard deviation for the number of steps were (7.838) and (0.216). The researcher sees a clear weakness in step length, which resulted in this number of steps. Additionally, the arithmetic mean and standard deviation for step frequency were (4.177) and (0.213), and this is normal due to the deficiency in step length among the runners. Furthermore, the arithmetic mean and standard deviation for step length were (1.276) and (0.036), and the researcher considers this one of the most influential factors in the other variables. The arithmetic mean and standard deviation for foot contact time were (0.134) and (0.002), which is normal as runners try to increase the push-off through longer contact time. Finally, the arithmetic mean and standard deviation for flight time were (0.806) and (0.024). The researcher considers it to be an ideal and good time for the runners. The arithmetic mean and standard deviation for the peripheral speed of the foot were (4.699) and (0.105), and this speed is within the normal range. However, the arithmetic mean and standard deviation for the peripheral speed of the arm were (2.284) and (0.338), which is not ideal compared to the speed of the foot.

Presentation of the results of the biomechanical variables correlation matrix, analysis, and discussion of them

In Table 3, Pearson's simple correlation values are displayed between the independent biomechanical variables and achievement as the dependent variable, as well as the simple correlation values among the independent variables themselves. The researcher used an inferential method to definitively judge the significance of the correlation, comparing the calculated correlation values with the table values at a degree of freedom (45) and a significance level (0.05). The determination was made that the correlations are statistically significant if the calculated values are (0.27 or more).

Table 4. The biomechanical variables correlation matrix and its analysis

Variables	Achievement	Reaction Time	Time for the First 10 Meters	Average Speed	Acceleration in the First 10 Meters	Number of Steps	Step Frequency	Step Length	Flight Time	Foot Contact Time	Peripheral Speed of the Foot	Peripheral Speed of the Arm
Achievement	1.000	-0.389	-0.626	-0.623	-0.698	0.114	-0.436	-0.126	0.129	0.543	0.114	-0.132
Reaction Time		1.000	-0.223	0.197	0.152	-0.336	0.029	0.362	-0.145	-0.072	-0.030	0.176
Time for the First 10 Meters			1.000	-0.997	-0.795	0.028	0.804	-0.013	0.201	0.310	0.149	0.004
Average Speed				1.000	0.823	0.019	0.833	-0.032	-0.182	-0.309	-0.140	-0.025
Acceleration in the First 10 Meters					1.000	0.198	0.783	-0.173	-0.068	-0.294	-0.107	-0.021
Number of Steps						1.000	0.517	-0.984	0.447	0.068	-0.041	-0.038
Step Frequency							1.000	-0.538	0.045	-0.204	-0.155	-0.015
Step Length								1.000	-0.445	-0.016	0.042	0.009
Flight Time									1.000	0.289	0.128	0.194
Foot Contact Time										1.000	0.051	0.057
Peripheral Speed of the Foot											1.000	-0.098
Peripheral Speed of the Arm												1.000

From the correlation matrix, we notice that the highest correlation values between acceleration in the first 10 meters, the average speed for the first 10 meters, and time for the first 10 meters with achievement in the 100-meter sprint event are (-0.698), (-0.626), and (-0.623), respectively. This indicates that these variables are the most independent and capable of explaining a significant portion of the variation in achievement and, therefore, have a high potential for predicting achievement. As for foot contact time, step frequency, and reaction time, their correlation values with achievement were (-0.543), (-0.436), and (-0.389), respectively. This implies a correlational relationship between these variables and achievement. As for the remaining variables, the peripheral speed of the foot, the peripheral speed of the arm, step length, flight time, and the number of steps, their correlation values with achievement were the weakest, with values of (0.114), (-0.132), (-0.126), (0.129), and (0.114), respectively. This indicates that there is no significant correlation between these variables and achievement.

Presenting the results of the contribution percentages of the independent variables to the achievement, analyzing them, and discussing them

The researcher utilized multiple correlations to find the relationship between several variables simultaneously and employed a significance test for the contribution percentage, as shown in Table 5.

Table 5. The contribution percentages of the independent variables to the achievement

Variables	Correlation Coefficient R	Contribution Percentage R2	Adjusted Square	Error Percentage
Reaction Time, Time for the first 10 meters , Average speed, Acceleration in the first 10 meters, Number of steps, Step frequency, Step length, Foot contact time, Flight time, Peripheral Speed of the Foot, Peripheral Speed of the Arm.	0.865	0.749	0.665	0.1761

Table 5 in the second column shows the values of multiple correlations between the independent variables and the achievement. After calculating the highest simple correlation value for the independent variable (acceleration in the first 10 meters) (-0.698), the rest of the independent variables are explored using multiple correlations. It was found that the acceleration variable in the first 10 meters, the average speed for the first 10 meters, and the time for the first 10 meters formed the highest correlation value in the dependent variable (achievement). Subsequently, the variable of average speed formed the highest correlation value with the variable of time for the first 10 meters in the dependent variable of achievement (-0.997). Following that, the variable (step length) formed the highest correlation value with the variable (number of steps) in the dependent variable (achievement) (-0.984). Then, the variable (step frequency) formed the highest correlation value with the variables (reaction time, average speed, and acceleration) in the dependent variable values, with achievement at (0.804), (0.833), and (0.783). These variables are among the primary factors that have a direct impact on the distance covered in sprinting.

The results revealed significant correlations between the variables step frequency, acceleration in the first 10 meters, and average speed (0.823) and (0.833), which are some of the most important relationships in the matrix. As for the other correlations between the remaining variables, the results showed either weak or no significant correlations. The researcher attributes this to the low numerical values achieved by the runners, which did not meet the statistical requirements at the very least.

The researcher utilized the calculation of the coefficient of determination (as shown in the second column), "since the coefficient of determination indicates the percentage contribution of the independent variables to the variation that occurs in the dependent variable. It represents the percentage of the explained variations to the total variations" (Ayasirah, 2010). Through it, we can determine the potential of independent variables to explain the amount of variation in the dependent variable (achievement). As we can observe, the last model has the highest contribution percentage, meaning that these variables can explain 74.9% of the achievement.

Table 6. The analysis of variance (ANOVA) for the significance of the regression

Model	Sum of Squares	df	Mean Square	F	Sig
Regression	3.052	11	0.277	8.941	0.00
Residual	1.024	33	0.031		
Total	4.077	44			

After observing the results in Table (6), it is possible to accept the alternative hypothesis and reject the null hypothesis. Table 6, which contains the F-value under a significance level of 0.05, indicates statistical significance.

DISCUSSION

The researcher attributes these results to both physiological and mechanical aspects. One of the most significant physical abilities associated with the 100-meter competition is the ability to endure rapid force, which some researchers consider to be the ability to maintain a high level of force through rapid contractions for a relatively long time against a high level of external resistance (Al-Rubadi, 2004). Additionally, the instantaneous force exerted in each step, representing the muscles' ability to overcome external forces in the shortest possible time with each ground contact (in every step), is also a significant factor (Sabri & Al-Kateb, 1980). The researcher believes that most of the sprinters work to achieve a noticeable increase in step length during this distance to maintain their average speed. At the same time, step frequency naturally decreases during the speed endurance phase, which is after 70 meters and towards the finish line, leading to an overall increase in time (the arithmetic mean for achievement is 10.89).

The researcher considers this time not good in general, which reflects on the starting variables up to the first 10 meters. It is assumed that athletes should be encouraged to maintain the same step frequency as much as possible while increasing step length proportionally. This could mean that a sprinter capable of covering short distances at high speed might also be able to cover longer distances at a slightly lower speed. The researcher agrees with Thorne and McKay that this may be a result of the training programs prepared by coaches, and it is necessary to focus on developing speed endurance. This aspect is one of the evaluation criteria for the training level (Thorne & McKay, 2008). As for the contribution percentage of acceleration in this specific distance (first 10 meters), the researcher attributes it to the fact that this phase is effective, and athletes often train for it from the special preparation period to the competition phase. Low-start training exercises are routines that sprinters use three to four times a week. These training exercises contribute to the development of effective acceleration, which helps reduce the time needed to cover a distance due to performing continuous repetitions at high-intensity speeds. This enhances the efficiency of the working muscles, thereby positively impacting achievement.

The researcher's perspective aligns with the views of Jamila and Ali Shabout, as they emphasize the execution of the start with the maximum force applied to reach the highest possible speed in progressive acceleration (Abdul Ridha & Al-Sudani, 2020). Finally, the researcher agrees with several studies regarding the importance of integrating the performance phases, as indicated by (Al-Fadhli et al., 2016; Majeed et al., 2016; Abdul Mohsen, 2018; Saleh et al., 2014; Hameed, 2019) state that speed events involve four fundamental stages: the start, acceleration, maximum speed, and maintaining maximum speed. Each stage complements the others, and each sprinter has unique characteristics. Some rely on starting and acceleration, others on maintaining maximum speed, and some aim to delay the deceleration phase as long as possible. The key factor in controlling race outcomes is the length and frequency of steps. Speed remains one of the most challenging abilities for coaches to develop, as it is an inherited trait. Regarding the time for the first 10 meters, acceleration, and average speed, the researcher believes that the contribution of these variables to the total time is due to the standard training exercises practiced by the sample individuals.

Considering that the time for this distance is effective and influential in achieving good acceleration, and since all training focuses on this aspect, a significant contribution percentage for this time to the achievement has been observed. Additionally, the type of training exercises used by the sprinters to reach maximum speed, especially plyometric (fast strength) training, plays a crucial role. The researcher agrees with Sareeh Al-Fadhli in stating that achieving success and reaching a high level in track and field activities is not solely achieved through using the best scientific methods in sports training, but also as a result of the proper use of modern measurements and tests, scientific planning accompanied by the results of relevant tests to the laws of motion, and their practical application in training (Ajeel & Al-Fadhli, 2020). Many scientific studies have also demonstrated the importance of developing and improving muscle strength and explosiveness, especially the specific strength of muscles involved in performing rapid movements. Therefore, it has become clear that the strength of the muscles involved in rapid sprinting significantly determines the maximum speed of athletes. This relies on various types of jumping exercises, which constitute essential training units within the general training program for sprinters. Regarding step length and frequency, the lack of significance in step length and the significance in step frequency are quite obvious.

This is because the sprinter starts from rest (zero acceleration), and shorter steps help increase the acceleration rate, leading to a correlation between other variables, such as contact time and flight time. The increase in force occurs through an extension of the contact time to generate high-force push-off values. Finally, after achieving an optimal time for the first 10 meters, the results showed a significant correlation among the variables, as evidenced by achieving high values for the F-test and the coefficient of determination. The researcher agrees with a group of researchers on the importance of utilizing the science of biomechanical analysis and measurement devices that can simulate performance, such as DYNA FOOT. Hasan and Kambash recommend "the importance of measuring the ability to endure speed and various biomechanical variables in achieving success in the 400-meter hurdles race" (Hasan & Kambash, 2023). Furthermore, her previous study with Faten emphasized the importance of using biomechanical analysis, a science that discovers and accurately identifies points of weakness and strength (Mualla & Hussein, 2022).

The researcher emphasizes the importance of the time taken to cover the first 10 meters, as evidenced by a previous study conducted with Jasim, which indicates the time taken to cover the first 20 meters in the 100- and 200-meter races has a significant and influential contribution to the final achievement. This is due to the training programming for starts, reactions, and acceleration within the daily training regimen for athletes up to 60 meters (Jasim & Hussien, 2023). The researcher believes that the extracted numerical values and their contribution percentages provide important indicators for coaches to program their sprinters' training. This aligns with Kareem and Abdul-Mohsen in "adopting the data considered by the researchers as fundamental in training sprinters for the 100-meter hurdles event" (Kareem and Abdul-Mohsen, 2023). The researcher sees the possibility of utilizing the training of the variables under study through high-intensity repetitive and periodic loading, given their impact on sprinters, both at the beginning of the race in terms of momentary forces and at the end of the race in terms of speed endurance and strength endurance. Hasan and Gambash are mentioned in another study regarding sprinting, stating that "there should be a focus on both high-intensity interval training and high-repetition training to develop speed endurance and strength endurance for the 400-meter race" (Hasan & Gambash, 2023). The researcher emphasizes the importance of developing physical capacities alongside biomechanical indicators, as previous research with Jamal and Sabeeh has shown that "physical capacities have a direct impact on mechanical variables in improving the final achievement (Jamal & Sabeeh, 2022). The researcher finds that it is essential to have the necessary tools and assistive devices in the training process to enhance the value of contributing variables. In this regard, the researcher agrees with Al-Dulaimi that creating cost-effective assistive tools that serve the training and educational goals of young trainees and using a more diverse range of assistive tools can increase the effectiveness of learning the art of running the 100 meters (Al-Dulaimi, 2022). As the topics of biomechanics are related to performance technique, the researcher aims to connect the current researched variables with compatibility exercises due to their importance in improving these variables. In this regard, the researcher agrees with Ghanim and Jaleel that multiple exercises that align with each athlete's abilities lead to the development of physical capabilities and consequently enhance their technical performance (Ghanim & Jaleel, 2022). The researcher once again sees the importance of physical capabilities in enhancing achievement through their contribution percentage to mechanical variables. The researcher has previously demonstrated in her previous study with Challoub and Sabeeh that it was concluded that there is a significant correlational relationship between the standard scores of physical tests for acceptance and the achievement in the 100 meters (Challoub & Sabeeh, 2021). Therefore, those involved in performance development should pay attention to the aspects mentioned.

Conclusion

The variables (acceleration in the first 10 meters, average speed for the first 10 meters, and time for the first 10 meters) achieved the highest correlational relationships with performance in the men's 100-meter sprint event. Acceleration in the first 10 meters is considered the most independent biomechanical variable contributing to achievement in the men's 100-meter sprint event. An increase in variables (foot contact time, step frequency, and reaction time), whether in an inverse or direct manner, assists the sprinter in achieving a high-performance time.

Recommendations

It is essential to focus training efforts on developing biomechanical variables that have shown the highest levels of contribution to achievement. The necessity of incorporating the study's findings into the development of training curricula to address weaknesses in both the physical and technical aspects. The necessity of including exercises based on quantitative kinematic analysis in training programs and curricula designed to develop mechanical aspects of technical performance in the men's 100-meter sprint event.

Conflict of interest

The authors declare no conflict of interest. In addition, no financial support was received.

Ethics Statement

The interventional study was approved by the University of Baghdad, College of Physical Education and Sports Sciences for Women.

Author Contribution

Study Design, SBS and SD; Data Collection, MM; Statistical Analysis, SD; Data Interpretation, MM and SD; Article Preparation, SBS and SD; Literature Search, SBS and MM. All authors read and accepted the published version of the manuscript.

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