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RESEARCH ARTICLE

Vertical Resistance and Its Relationship with Speed-Strength and Biomechanical Variables During the Takeoff Phase and the Performance of Selected Activities in Individual and Team Sports

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Abstract

Jumping ability is a fundamental variable in many sports, as its execution requires an integration of muscular strength and certain biomechanical variables. This is particularly evident in gymnastics jumping events and jump shots in ball games, both of which rely on a high level of vertical resistance. Vertical resistance serves as an indicator of an athlete's ability to overcome their body weight while counteracting gravitational force to achieve optimal performance. As such, it is considered one of the key factors in movements that demand explosive power and speed. The researchers believe that despite the significant relationship between vertical resistance, speed-strength of the arms and legs, and certain biomechanical variables in determining athletic performance across various sports activities, the limited number of studies addressing this relationship makes it difficult to provide precise scientific data on its importance. This is particularly relevant to female students in the College of Physical Education and Sport Sciences, who often struggle with performing activities that require jumping or shooting while airborne with proper technical execution. This underscores the need for a more comprehensive and in-depth study of the factors influencing such performance. This research aims to bridge the existing knowledge gap by analyzing these relationships among a sample of female students from the College of Physical Education and Sport Sciences for Women. The study seeks to highlight the key factors affecting student performance. Accordingly, the research problem is framed in the following question: What is the relationship between vertical resistance, physical abilities, biomechanical variables, and the execution of sports activities (high jump, jump shooting, and vaulting) among third-year female students? The study aimed to examine the relationship between vertical resistance, speed-strength of the arms and legs, and certain biomechanical variables during the take-off phase, as well as their impact on the execution of vaulting, jump shooting accuracy in handball, and jump shooting accuracy in basketball. The researchers hypothesized that there is no statistically significant relationship between vertical resistance and speed-strength, nor between vertical resistance and certain biomechanical variables during the take-off phase. Additionally, they posited that no statistically significant relationship exists between vertical resistance and the performance or accuracy of the examined activities. A descriptive research methodology was employed, with the study sample consisting of eight third-year female students from the College of Physical Education and Sport Sciences for Women, selected through purposive sampling.

Keywords: Vertical resistance, Speed-strength, Biomechanical variables, Vaulting performance, Shooting accuracy in handball and basketball

1. Introduction

Jumping ability is a fundamental variable in many sports, as its execution requires an integration of muscular strength and certain biomechanical variables. This is particularly evident in gymnastics jumping events and jump shooting skills in ball games, both of which rely on a high level of vertical resistance. Vertical resistance serves as an indicator of an athlete's ability to overcome their body weight while counteracting gravitational force to achieve

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optimal performance. As such, it is considered one of the key factors in movements that demand explosive power and speed.

With advancements in sports sciences, analyzing the biomechanical variables associated with vertical resistance and examining their impact on athletic performance has become essential for enhancing proficiency in various sports activities. The significance of this study lies in its focus on analyzing the relationship between vertical resistance, speed-strength, certain biomechanical variables, and the execution of vaulting, jump shooting accuracy in basketball, and shooting accuracy in handball. The study aims to contribute to the development of educational programs designed to improve students' technical and physical abilities by providing research-based scientific insights that aid in optimizing athletic performance. Numerous studies emphasize the importance of integrating biomechanical analysis with physical abilities to enhance sports performance, particularly in activities requiring high jumps and shooting while airborne.

Bartlett states that "understanding the dynamics of movement and the relationship between physical and mechanical variables contributes to improving athletic performance" [6, p. 56]. Similarly, Zatsiorsky and Kraemer emphasize that "examining the relationship between vertical resistance and other variables helps in developing specialized training strategies for each activity" [19, p. 94].

The researchers argue that despite the importance of the relationship between vertical resistance, speed-strength of the arms and legs, and certain biomechanical variables in athletic performance across various sports, the limited number of studies addressing this relationship makes it difficult to obtain precise scientific data on its significance. This issue is particularly relevant given that many female students in the College of Physical Education and Sport Sciences struggle with performing activities that require jumping or shooting while airborne with proper technical execution. This challenge underscores the need for a more comprehensive and in-depth study of the factors influencing such performance.

Abdel-Aziz and Karara assert that "research integrating physical abilities with biomechanical analysis contributes to enhancing athletic performance and provides scientific solutions to improve the execution of sports activities such as high jumping, jump shooting, and vaulting" [2, p. 59].

Therefore, given the scarcity of studies examining the relationship between vertical resistance, the physical abilities of the arms and legs, biomechanical variables, and the execution of the investigated activities, this research aims to address the existing knowledge gap. By analyzing these relationships among a sample of female students from the College of Physical Education and Sport Sciences for Women, the study seeks to highlight the key factors influencing student performance. Additionally, it aims to provide scientific data and findings that facilitate a better understanding of the significance of these relationships, ultimately contributing to improving students' performance and enhancing training curricula.

Accordingly, the research problem is framed in the following question:

- What is the relationship between vertical resistance, speed-strength of the arms and legs, biomechanical variables, and the execution of vaulting, shooting accuracy in handball, and scoring accuracy in basketball among third-year female students at the College of Physical Education and Sport Sciences for Women?

2. Research hypotheses

1. There is no statistically significant relationship between vertical resistance and speed-strength.
2. There is no statistically significant relationship between vertical resistance and certain biomechanical variables during the take-off phase in the investigated activities.
3. There is no statistically significant relationship between vertical resistance and the execution of vaulting.
4. There is no statistically significant relationship between vertical resistance and both jump shooting accuracy in handball and scoring accuracy in basketball.

3. Research domains

Human Domain: Third-year female students at the College of Physical Education and Sport Sciences for Women, University of Baghdad.

Time Domain: The study was conducted from January 20, 2025, to March 3, 2025.

Spatial Domain: The study was carried out in the indoor artistic gymnastics hall, as well as the outdoor basketball and handball courts.

4. Methodology and procedures

The research population consisted of third-year female students at the College of Physical Education and Sport Sciences for Women for the 2024–2025 academic year, totalling 40 students. The study sample comprised 8 students selected through purposive sampling. Additionally, a pilot study was conducted on 4 students outside the main research sample. The selected sample represented 30% of the total research population. To ensure homogeneity, the researchers

assessed variables such as height, age, and body mass, as presented in the table below.

The results indicated that the sample was homogeneous, as the skewness coefficient fell within the range of (±1), signifying a normal distribution.

The researchers utilized various sources, including Arabic and foreign references, the internet, personal interviews, and data recording and extraction forms. The equipment and tools used in the study included: one vaulting platform, four accuracy target squares (60 × 60 cm), eight handballs, two basketballs, a medical scale for measuring body weight, a high-speed video camera capturing 60 frames per second, a data collection form, and an assisting research team.

5. Research procedures

After reviewing relevant literature, previous studies, and consulting experts and specialists in gymnastics, the researchers selected a set of appropriate tests to achieve the objectives of the current study.

5.1. First: Lay-up shooting test [5, p. 5]

- **Objective of the Test:**
  To measure the accuracy of lay-up shooting.
- **Test Procedure:**
  The participant stands behind the free-throw line and begins running towards the basket, taking three legal steps (right-left-jump or vice versa) before executing the lay-up shot.
- **Scoring Method:**
  Each participant is given 10 attempts (5 with the right hand and 5 with the left hand). One point is awarded for each successful shot, and the success rate is calculated as a percentage of the total attempts.

5.2. Second: High jump shooting accuracy test [9, p. 5]

- **Objective of the Test:**
  To measure the accuracy of high jump shooting.
- **Equipment Used:**
  Eight handballs and four-square target areas (60 × 60 cm) placed in each corner of the goal.
- **Test Procedure:**
  The participant stands behind the starting line directly in front of the goal while holding the ball. Upon hearing the signal, they take 2–3 approach steps and then execute a high jump shot, aiming at one of the designated target squares. The take-off must occur from a distance of at least 7 meters from the goal. The participant must not exceed three approach steps, touch the take-off line with their foot, or perform the shot without being airborne. Each participant is allowed eight attempts, with two shots directed at each target square.
- **Scoring Method:**
  One point is awarded for each successful shot, with a maximum possible score of eight points. A shot is considered successful if the entire circumference of the ball passes through the designated target square. Each participant is given two trials, and the better score is recorded as the final result.

5.3. Third: Straddle and tuck jump test on the vaulting platform

The performance of the straddle and tuck jump on the vaulting platform was evaluated by four judges. Each skill was graded out of 10 points, with the highest and lowest scores being excluded. The remaining two scores were then averaged to determine the final evaluation score.

5.4. Fourth: Knee flexion and extension test in 20 seconds [4, pp. 2–3]

- **Objective of the Test:**
  To measure the speed-strength of the legs.
- **Equipment Used:**
  A stopwatch.
- **Test Procedure:**
  From a standing position, the participant repeatedly bends and fully extends the knees for 20 seconds without allowing any body part to touch the ground or any external support.
- **Scoring Method:**
  The total number of complete knee flexion and extension movements performed within 20 seconds

Table 1. Homogeneity of the research sample in terms of mass, height, and age.

Variables	Unit of Measurement	Mean	Standard Deviation	Median	Skewness Coefficient
Mass	Kg	70	12.899	65	0.697
Height	cm	162.33	4.082	163	0.492
Age	Year	21	3.196	20	0.484

Table 1 illustrates the homogeneity of the research sample in terms of body mass, height, and age. The skewness coefficients for all variables fall within the acceptable range (±1), indicating a normal distribution and confirming the sample's homogeneity.

is recorded. Each participant is given two attempts, and the better score is recorded as the final result.

5.5. Fifth: Front support arm flexion and extension test (10 seconds) [12, p. 48]

- **Objective of the Test:**
  To measure the speed-strength of the arms.
- **Performance Description:**
  The participant assumes a front support position on the ground with the body held in a straight line. Upon receiving the signal, they perform as many complete push-ups as possible within 10 seconds. Each repetition requires the chest to touch the ground during arm flexion, followed by a full extension of the arms. The participant must maintain proper form throughout the test, ensuring full range of motion in each repetition.
- **Scoring Method:**
  The final score is determined by counting the total number of correctly executed flexion and extension repetitions performed within 10 seconds.

5.6. Sixth: Vertical resistance coefficient test [8, pp. 170–176]

- **Objective of the Test:**
  To measure the vertical resistance coefficient.
- **Performance Description:**
  The vertical resistance coefficient is measured during maximum jumping. The participant performs 10 consecutive jumps, maintaining straight legs and keeping their hands positioned at the waist throughout the test.
- **Scoring Method:**
  The vertical resistance coefficient is calculated based on the **six** central rebound jumps (from jump number 3 to jump number 8) out of the total 10 jumps performed.

6. Determination of biomechanical variables

After reviewing a wide range of sources and research studies, the researchers presented a set of biomechanical variables to the scientific committee for evaluation. The variables were approved following certain modifications based on expert recommendations.

7. Pilot study

The pilot study was conducted on Monday, January 20, 2024, using a sample of four female students who were not part of the main research sample. The purpose of this study was to assess the suitability of the tests for the research participants, determine the optimal camera placement, evaluate the adequacy of the equipment and tools used, and examine the efficiency of the assisting research team in carrying out the tests.

8. Main experiment

The main experiment was conducted on Monday and Tuesday, February 3–4, 2025, at 11:00 AM, involving eight female students from the College of Physical Education and Sport Sciences for Women. On the first day, the participants' execution of the targeted skills was recorded, while on the second day, tests measuring speed-strength were conducted in outdoor courts and the indoor artistic gymnastics hall. Before the tests were administered, the researchers provided a detailed explanation of the testing procedures to ensure accurate execution by the participants.

9. Statistical analysis

The researchers utilized the Statistical Package for the Social Sciences (SPSS) to process the data and analyze the results statistically.

10. Presentation and discussion of results

It is evident from Tables 2 to 5 that the skewness coefficient, ranging between 0.275 and 0.91, indicates that the data distribution of the research sample for the studied variables follows a normal distribution.

Table 2. It presents the mean, standard deviation, median, and skewness coefficient for vertical resistance and speed-strength of the arms and legs.

Variables	Mean	Standard Deviation	Median	Skewness Coefficient
Vertical Resistance Coefficient	11.88	0.835	12.00	0.277
Speed-Strength of the Arms	6.13	1.126	7.00	0.488
Speed-Strength of the Legs	17.63	1.76	18.00	0.275

Table 3. It presents the mean, standard deviation, and median for selected biomechanical variables in the performance of straddle and tuck jumps on the vaulting platform.

Variables	Unit of Measurement	Mean	Standard Deviation	Median	Skewness Coefficient
Straddle Jump on the Vaulting Platform					
Takeoff Angle	Degrees	69.38	3.583	70.00	0.681
Body Inclination	Degrees	44.28	6.81	43.90	0.446
Push-Off Time	Seconds	0.69	0.102	0.71	0.66
Knee Extension Angle at Push-Off	Degrees	159.37	13.70	158.50	0.008
Tuck Jump on the Vaulting Platform					
Takeoff Angle	Degrees	68.43	3.223	68.00	0.312
Body Inclination	Degrees	43.06	4.85	43.75	0.147
Push-Off Time	Seconds	0.788	0.067	0.790	0.451
Knee Extension Angle at Push-Off	Degrees	159.75	7.478	160.00	0.919

Table 4. It presents the mean, standard deviation, and median for selected biomechanical variables in the accuracy of high jump shooting in handball.

Variables	Unit of Measurement	Mean	Standard Deviation	Median	Skewness Coefficient
Takeoff Angle	Degrees	76.62	5.39	78.50	0.71
Takeoff Time	Seconds	0.26	0.051	0.25	0.89
Body Inclination	Degrees	14.68	4.182	15.00	0.47
Elbow Joint Angle	Degrees	95.37	13.90	99.00	0.69
Knee Joint Angle	Degrees	162.62	6.88	165.00	0.88

Table 5. It presents the mean, standard deviation, and median for selected biomechanical variables in the performance of lay-up shooting in basketball.

Variables	Unit of Measurement	Mean	Standard Deviation	Median	Skewness Coefficient
Takeoff Angle	Degrees	89.62	1.40	89.50	0.48
Takeoff Time	Seconds	0.25	0.15	0.24	0.74
Body Inclination	Degrees	7.62	2.26	8.00	0.36
Elbow Joint Angle	Degrees	113.50	27.29	104.50	0.69
Knee Joint Angle	Degrees	162.25	9.80	159.00	0.62

11. Results discussion

To examine the impact of the vertical resistance coefficient on speed-strength and selected biomechanical variables during the preparatory phase, as well as its influence on the performance of certain activities in both individual and team sports, the researchers utilized Pearson's correlation coefficient. As shown in Table 6, a significant correlation was found between vertical resistance and speed-strength of the legs and arms. The presence of such a relationship reinforces the idea that in most jumping activities, where vertical resistance is a key factor, a high level of muscular strength is necessary. This strength plays a critical role in overcoming resistance and positively influences performance.

Ali states that "most activities involving vertical resistance, such as jumping or throwing, require increasing levels of muscular strength as vertical resistance increases. In other words, an athlete must generate greater force to overcome vertical resistance" [3, p. 2745].

Similarly, a recent study by Al-Sayed examined the development of the vertical resistance coefficient in relation to foot movement speed and the execution of back and circular kicks among Taekwondo athletes and confirmed the existence of a significant

Table 6. It presents the correlation between the vertical resistance coefficient, speed-strength of the arms, and speed-strength of the legs.

Variables	Mean	Standard Deviation	Correlation Coefficient (R)	Sig	Significance
Vertical Resistance Coefficient	11.88	0.835			
Speed-Strength of the Arms	8.13	1.126	0.627	0.096	Significant
Speed-Strength of the Legs	17.63	1.76	0.548	0.026	Significant

* N equals 8 at a significance level of (0.05).

Table 7. Presents the correlation between the vertical resistance coefficient and selected biomechanical variables in the performance of straddle and tuck jumps on the vaulting platform.

Variables	Mean	Standard Deviation	Correlation Coefficient (R)	Sig	Significance
Vertical Resistance Coefficient	11.88	0.835			
Straddle Jump on the Vaulting Platform					
Takeoff Angle	69.38	3.583	0.221	0.599	Non- Significant
Body Inclination	44.28	6.81	0.241	0.565	Non- Significant
Push-Off Time	0.69	0.102	0.792	0.019	Significant
Knee Extension Angle at Push-Off	159.37	13.70	0.628	0.095	Significant
Tuck Jump on the Vaulting Platform					
Takeoff Angle	68.43	3.223	0.428	0.290	Non- Significant
Body Inclination	43.06	4.85	0.262	0.531	Non- Significant
Push-Off Time	0.788	0.067	0.758	0.029	Significant
Knee Extension Angle at Push-Off	159.75	7.478	0.904	0.052	Significant

relationship between vertical resistance and speed-strength of the legs [10, p. 150].

The researchers explain the significance of the relationship between vertical resistance and the speed-strength of the arms, attributing it to the fact that performing any exercise involving vertical resistance requires the athlete to exert greater force to move the arms. This increased effort can lead to an improvement in speed-strength of the arms, which in turn enhances performance in activities that demand rapid movement.

Hoff highlights the importance of the relationship between vertical resistance and speed-strength of the arms, emphasizing the role of resistance in developing strength and motor control. He states that when performing exercises involving vertical resistance, the athlete must exert greater force to move the arms, leading to an improvement in speed-strength. This enhancement contributes to better performance in sports activities that require quick and efficient movement [11, p. 175].

Similarly, Komi & Häkkinen point out that, according to Newton's Second Law, an increase in vertical resistance requires greater acceleration to enhance the muscles' ability to generate force rapidly. Additionally, the increased torque around the arm joints due to vertical resistance stimulates the muscles to develop strength at a faster rate [15, pp. 1–63].

Table 7 shows a significant correlation between vertical resistance and push-off time, as well as with the knee extension angle at push-off in the performance of straddle and tuck jumps on the vaulting platform. This finding highlights the mutual interactive relationship between these variables.

Bobbert states that "push-off time is directly related to an athlete's ability to generate sufficient force to counteract gravity. Reducing the time required to push off the ground is associated with a greater ability to overcome vertical resistance more quickly and efficiently" [7, p. 1184].

This aligns with previous studies indicating that the push-off phase and take-off movement represent the final outcome of the body's interaction with the ground, where the generated force determines the height and quality of the center of mass elevation [12, p. 55].

Based on the above, it is evident that an increase in vertical resistance requires the performer to generate greater force within a limited time, leading to a reduction in push-off time to achieve sufficient acceleration of the body. Additionally, this increase necessitates adjustments in the knee extension angle, which contributes to a higher jump elevation.

The findings of the study conducted by Kellis and Katis indicate that "extending the knee joint angle during the push-off phase significantly enhances jumping ability. The study results further confirmed that the optimal knee joint angle at the moment of take-off typically ranges between 120 to 150 degrees to achieve the best jumping performance" [14, pp. 285–290].

The researchers attribute the lack of a significant correlation between vertical resistance and both the take-off angle and body inclination to several factors, including the possibility that the students' execution of the skill was not at a sufficiently high level to produce a clear effect of resistance on these variables.

Furthermore, Newton states that "the significant relationship between vertical resistance and vaulting performance suggests that the effect of resistance is more pronounced on factors directly influencing height and generated force, rather than necessarily on the take-off angle or body inclination. These latter variables may be more influenced by other factors, such as an individual's take-off strategies and the fluidity of movement execution" [18, pp. 17–38].

Table 8. It presents the correlation between the vertical resistance coefficient and selected biomechanical variables in the accuracy of high jump shooting in handball.

Variables	Mean	Standard Deviation	Correlation Coefficient (R)	Sig	Significance
Vertical Resistance Coefficient	11.88	0.835			
Takeoff Angle	76.62	5.39	0.729	0.147	Non- Significant
Takeoff Time	0.26	0.051	0.915	0.045	Significant
Body Inclination	14.68	4.182	0.830	0.036	Significant
Elbow Joint Angle	95.37	13.90	0.712	0.041	Significant
Knee Joint Angle	167.62	6.88	0.878	0.065	Significant

Table 9. It presents the correlation between the vertical resistance coefficient and selected biomechanical variables in the accuracy of lay-up shooting in basketball.

Variables	Mean	Standard Deviation	Correlation Coefficient (R)	Sig	Significance
Vertical Resistance Coefficient	11.88	0.835			
Takeoff Angle	89.62	1.40	0.639	0.198	Non- Significant
Takeoff Time	0.25	0.51	0.992	0.004	Significant
Body Inclination	7.62	2.26	0.806	0.014	Significant
Elbow Joint Angle	113.50	27.29	0.945	0.039	Significant
Knee Joint Angle	162.25	9.80	0.913	0.046	Significant

Tables 8 and 9 show a significant correlation between vertical resistance and the variables take-off time, body inclination, elbow joint angle, and knee joint angle. However, no significant correlation was found between vertical resistance and the take-off angle in both lay-up shooting in basketball and high jump shooting in handball.

Bobbert states that "take-off or push-off time is directly related to an athlete's ability to generate sufficient force to counteract gravity. Therefore, reducing the time required for ground push-off is associated with a greater ability to overcome vertical resistance more quickly and efficiently" [7, p. 1184].

Additionally, the same tables indicate a significant correlation between vertical resistance and trunk inclination angle. Kellis and Katis explain that at the moment of push-off and take-off, the body moves against gravitational force. As vertical resistance (gravity) increases, the trunk naturally adopts an optimal inclination angle to maintain body balance during push-off. In jumping activities that involve high vertical resistance, a greater trunk inclination is required to maximize the efficiency of the push-off [14, p. 287].

The relationship between vertical resistance and knee extension angle is a dynamic and interconnected one. Any increase in vertical resistance necessitates a greater knee extension angle to achieve maximum push-off force. This suggests that an athlete must enhance their push-off strength to generate the required height in response to increased vertical resistance.

Researchers in biomechanics emphasize that knee flexion and extension play a crucial role in performance, particularly full extension at the final moment of ground push-off, as it is essential for generating the maximum possible force [1, p. 187].

Additionally, some studies highlight the importance of increasing the range of motion (joint angles) for both the knee and hip joints, as it is a key requirement for executing correct and efficient push-off techniques [17, p. 106].

The researchers explain that the lack of a significant correlation between vertical resistance and take-off angle in the studied skills, despite the take-off angle being a critical factor in determining the vertical component of movement, can be attributed to several factors. Jump shooting in handball and basketball is influenced by multiple variables, including the fluidity of movement between the upper and lower limbs at the moment of execution, as well as push-off force and timing.

Lees states that "vertical resistance has a greater effect on the vertical force output rather than on the take-off angle. An athlete may compensate for the impact of vertical resistance by increasing push-off force without necessarily altering the take-off angle" [16, pp. 1–15].

Table 10 reveals a significant correlation between vertical resistance and the performance of straddle and tuck jumps on the vaulting platform, as well as between vertical resistance and shooting accuracy in basketball and handball.

Many sports activities that involve landing from a height, jumping, shooting while airborne, or performing vaults in gymnastics pose a challenge for a large number of students in the College of Physical Education and Sport Sciences. Many of them struggle with performance deficiencies when executing such activities.

Table 10. It presents the correlation between the vertical resistance coefficient and the accuracy and performance of the investigated activities.

Variables	Mean	Standard Deviation	Correlation Coefficient (R)	Sig	Significance
Vertical Resistance Coefficient	11.88	0.835			
Straddle Jump Performance	7.00	0.801	0.534	0.017	Significant
Tuck Jump Performance	6.625	0.744	0.834	0.010	Significant
Accuracy of High Jump Shooting in Handball	4.75	1.03	0.847	0.028	Significant
Accuracy of Lay-Up Shooting in Basketball	4.75	1.03	0.875	0.028	Significant

For this reason, some experts emphasize that analyzing biomechanical variables, including push-off speed, is essential for enhancing jumping skills in athletes. This underscores the importance of incorporating these elements into training programs [2, p. 59].

Bartlett adds that "studying the relationship between movement variables and physical abilities can significantly improve athletic performance, especially in activities that rely on explosive power and ground contact time" [6, p. 78].

Furthermore, studies have confirmed that "proper execution of movement patterns or motor tasks serves as a performance stimulus, ultimately leading to success in achieving optimal performance. Accuracy is the result of the interaction of multiple mechanical variables that function as interconnected chains" [20, p. 1108].

12. Conclusions

1. The researchers conclude that any movement involving vertical resistance must be countered with greater force in the movement of the arms and legs.
2. The researchers find that the participants did not utilize the take-off angle in a manner that serves the intended purpose of the studied skills.
3. The study reveals that the participants lacked sufficient experience in effectively using the take-off angle to enhance performance.
4. The findings indicate that the participants on the vaulting platform did not exhibit adequate control over their body inclination angle, preventing them from leveraging it effectively. Consequently, no significant correlation was observed between the body inclination angle and performance.
5. The researchers conclude that an increase in vertical resistance necessitates the generation of greater force within a short time, which in turn reduces push-off time to achieve sufficient acceleration.
6. The study confirms that greater knee joint extension contributes to an increase in jump height.
7. The researchers conclude that the independent variable (vertical resistance) plays a significant and positive role in enhancing both the performance and accuracy of the studied skills.

Author's declaration

Conflicts of interest: None.

We confirm that all tables and figures in this article are ours and written by the researchers themselves.

Ethical-Clearance: this manuscript approved by local ethical committee of physical education and sport sciences college for women on (January/2025).

Author's contributions

All contributions of this study were done by the researchers (A.T.) who get the main idea and work on writing and concluding also with number of experts, Mohammed Shaheed Abdul in Statistics, Manal M. Bayyat in revision, Noor Riyadh Rahim in translating,, Dr. Batoul Ahmed Salim in proofreading.

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