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ORIGINAL STUDY

Muscular Strength and Angular Ranges of Some Body Joints During the Take-Off Phase and Their Relationship to Vault Performance.

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Abstract

Artistic Gymnastics is a sport that requires high integration of physical, skillful, and mechanical abilities. Success in this sport depends on controlling coordinating the movements of body parts during different performance phases. The vaulting device requires the production of high speed and strength in a relatively short period of time because artistic performance goes through many essential phases including approaching, taking off, first vaulting, second vaulting, then landing. Previous studies reported that taking off is the most effective and decisive phases on achievement in vaulting. The goal of the study is to identify the relationship of muscular strength and joint angular range for some joints of the body in the take off and vault performance phases on the vaulting platform. To achieve this, the descriptive approach was used. The sample consisted of (10) female students from the first stage in the College of Physical Education and Sports Sciences for Women, who were selected purposively. The results showed that the mean score for jumping (opening) was (5.90) with a standard deviation of (1.853), while the mean score for body mass index (BMI) was (108.37) with a standard deviation of (1.210). The correlation coefficient was (0.654), indicating a moderate positive correlation between the studied variables. These results reflect the efficiency of converting muscular strength into effective motor skills during the take-off phase. Based on these findings, the study recommends that educational and training programs focus on developing lower limb muscular strength, and emphasizing its connection to specific skills required during the take-off phase on the vaulting platform.

Keywords: Muscular strength, Joint angular range, Take-off phase, Vault performance

1. Introduction

Artistic gymnastics is a sport that requires a high level of integration between physical, technical, and mechanical abilities. The success of the performance in this sport depends on the player's ability to control and coordinate the movements of body parts precisely during the performance phases. Vault performance goes through several basic phases, starting with the approach phase, then the take off phase, followed by the first and second take-off phases, and then the landing. Therefore, many experts emphasize that the take-off phase is one of the most important and crucial phases in performing jumping skills, as it contributes to generating the linear and angular momentum that allows the athlete to reach the appropriate height and complete the required aerial maneuvers during take-off (Hiley et al., 2015).

In light of scientific advancements in biomechanical analysis, the need has become urgent to study the mechanical variables associated with skill performance in gymnastics, given their crucial and fundamental role in interpreting movement patterns and identifying factors influencing successful performance.

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Recent studies indicate that vault performance in gymnastics depends largely on a range of physical and mechanical factors, particularly the muscular strength of the legs and the speed of approach. These variables contribute to generating the power and momentum necessary for the take-off phase, which positively impacts the height of the body's center of gravity and the quality of technical performance (Schärer et al., 2019). Biomechanical studies also confirm that the muscular strength of the legs is closely related to some biomechanical variables associated with the performance of jumping skills in gymnastics, such as the height of the body's center of mass, take-off time, and movement path during the performance phase, which directly affects the skill performance level of the jump as well as the judging score obtained by the athlete (Kochanowicz et al., 2016). In addition, Razzaq et al. (2019) pointed out that "Biomechanical analysis is a fundamental scientific tool for evaluating performance levels and identifying strengths and weaknesses, by studying biomechanical variables and comparing them to global standards, which contributes to improving athletic achievement." Moreover, many specialists point out that the angular ranges of the body's joints are important biomechanical variables that contribute to explaining the nature of movement. For instance, analyzing joint angles during movement performance helps in identifying how force is transferred through the body's kinetic chain and determining the efficiency of movement performance (Barreto et al., 2021).

The researchers believe that despite the great importance of these variables in explaining the mechanics of kinetic performance in gymnastics, most studies have focused on analyzing performance at this stage in advanced levels.

The researchers believe that there are few studies that have addressed these variables among students of the College of Physical Education for Women. Studying the relationship between muscular strength and joint angular ranges during the take-off phase of female students can contribute to a precise understanding of the factors influencing the learning and mastery of vaulting skills. Furthermore, the results of these studies can be used to develop teaching and training methods in gymnastics courses at the colleges of physical education and sports science. By monitoring the performance of freshmen female students at the College of Physical Education and Sports Sciences for Women during the execution of the vaulting performance (tuck – straddle), researchers observed a variation in the level of performance among the students, which was due to differences in muscle strength or angular ranges of the body joints during the take-off phase. Hence the need arose to study these variables and analyze the relationship between them in addition to the skill performance to provide scientific indicators that can be used to develop methods of teaching and training gymnastics skills in colleges of physical education and sports science.

Purpose of the study

The study aims to identify the relationship between muscular strength and joint angular ranges of some body joints during the take-off phase of vaulting performance (tuck – straddle) and the relationship between muscular strength and angular ranges of body joints during the take-off phase and vaulting performance.

Research hypotheses

- There is a significant correlation between muscular strength and vaulting performance (tuck – straddle).
- There is a statistically significant correlation between the angular ranges of some body joints during the take-off phase and the vaulting performance.
- There is a statistically significant correlation between muscular strength and the angular ranges of some body joints during the take-off phase.

Study scope

- ◦ **Human Domain:** freshmen female students in the College of Physical Education and Sports Sciences for Women.
- ◦ **Temporal Domain**: from 1/3/2026 to 31/3/2026.
- ◦ **Spatial Domain**: Artistic Gymnastics Hall in the College of Physical Education and Sports Sciences for Women.

2. Methodology and procedures

The research population was defined by the researchers as (33) freshmen female students in the College of Physical Education and Sports Sciences for Women. The research sample consisted of (18) students from Section (A). (8) students were excluded due to non-compliance, leaving (10) students selected purposively, representing 30.30% of the original population. Table 1 shows the homogeneity of the sample in terms of height, weight, and age.

The results in Table 1 indicate that the values of the skewness coefficient for all variables (height, mass, age, leg length) fall within statistically acceptable limits, which indicates that the data distribution is

Table 1. Shows the homogeneity of the sample (Mass – Height – Age – Leg Length).

Variables	Unit of Measurement	Mean	Median	Standard Deviation	Skewness
Body Mass	kg	51.10	50	14.114	1.123
Height	cm	161.20	160	4.614	1.653
Age	years	20.50	20	1.509	0.121
Leg Length	cm	91.50	91	19.098	2.575

relatively normal and there are no sharp deviations that affect the analysis. A skewness coefficient within the range of (±3) is considered acceptable in applied studies in the field of physical education and sports science, reflecting the homogeneity of the sample and the possibility of generalizing the results to an acceptable degree. From the above, it can be concluded that the sample has a suitable degree of homogeneity in the physical variables, which supports the integrity of the statistical procedures and gives reliability to the correlations. Previous studies (Čuk & Karácsony, 2004) indicate that the homogeneity of body characteristics (height and mass) among gymnasts contributes to the accuracy of skill performance analysis, especially in take-off skills.

The researchers used Arabic and foreign sources, the internet, personal interviews, expert opinion questionnaires, data entry forms, a Dell computer, CDs, one vaulting horse, one pair of gloves, a measuring tape, a tripod, the Kinovea motion analysis software, and 5cm wide adhesive tape. To determine the research variables, a number of tests were selected, including the explosive strength test for the legs (standing vertical jump) and the standing broad jump test.

Research procedures

Field procedures

First test: Explosive strength test of the legs (vertical jump from a standing position) (Musa, 2014, p.87).

The purpose of the test: to measure the explosive strength of the muscles of the leg associated with the take-off phase in vaulting on the vaulting horse.

Tools: Vertical vaulting measuring board or Vertec device.. Chalk or measuring tape.. Results recording form.

Method of performance: The testee stands next to the wall and raises the arm closest to the wall to determine the highest point that can be reached from a static and standing position. The testee bends his knees slightly and then jumps vertically upwards to the highest possible height while touching the wall, and the distance between the standing mark and the jump mark is calculated.

Recording: The tester gives three attempts and the best attempt is recorded in centimeters.

Second test: Standing broad jump test (Musa, 2014, p. 87).

The purpose of the test: to measure the muscular strength of the legs associated with the ground thrust phase during take-off.

Tools used: measuring tape, floor mat, chalk to mark the landing point.

Performance method: The testee stands behind the starting line with parallel feet, bends knees, swings arms, then jumps forward as far as possible and lands with both feet.

Recording: The distance is measured from the starting line to the nearest point the body touches after landing. Three attempts are given, and the best one is recorded in meters.

Pilot study

The researchers implemented the pilot study on Sunday, March 4, 2026 at 8:00 am on 4 students who were outside the sample (from section B) in the Gymnastics Hall for the College of Physical Education and Sports Sciences for Women. During the experiment, the explosive strength test for the legs (vertical jump from a standing position) and the standing broad jump test were performed. The horse jumping skill test (tuck – straddle) was conducted, and the members of the exploratory sample were filmed while performing the jumping (tuck – straddle) on the vualting horse with a video camera at a speed of 120 frames/second. Four days later, the test was repeated under the same conditions. The goal of the experiment was the following:

- Verifying the suitability of the tools and equipment used in the main experiment.
- Identifying potential challenges the researcher may encounter and finding appropriate solutions.
- Determining the placement, height, and distance of the cameras.
- Verifying the competence of the support team members.
- Deriving the scientific basis for the tests.

Identifying the most important biomechanical variables of the vaulting skill (tuck – straddle) on the vaulting horse was by Kinovea biomechanical analysis software.

Table 2. Shows the percentage of expert agreement for the biomechanical variables.

Biomechanical Variables	No.	skill
Knee joint angle at take-off	1	Vault (Tuck and Straddle)
Hip joint angle at take-off	2	
Ankle joint angle at push-off	3	
Trunk inclination angle at take-off	4	
Take-off angle of the center of mass	5	
Vertical velocity of the center of mass at take-off	6	
Push-off time	7	
Take-off time	8	

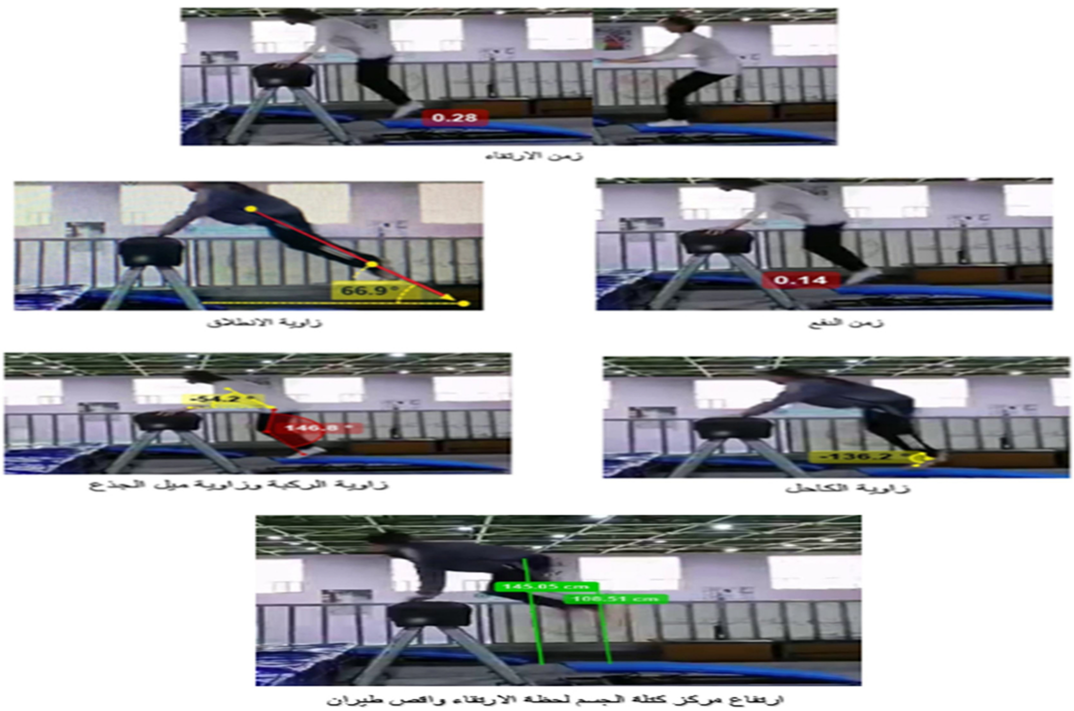

Fig. 1. Illustrates the values of the biomechanical variables.

After reviewing a number of scientific sources and research in the field of biomechanical artistic gymnastics, the researchers designed a questionnaire that included a set of biomechanical variables that are appropriately related to the performance of the gymnastics skills. It was presented to ten experts and specialists in the field of artistic gymnastics - biomechanics to choose the appropriate items.

After processing the forms and calculating the percentage, the researchers relied on the biomechanical variables that received an agreement rate of 80% from experts, as shown in Table 2. These variables are illustrated in Fig. 1.

Evaluating technical skills performance: The skill assessment was conducted based on the scores of (4) referees. Gymnastics experts were consulted to evaluate the technical performance of the sample, and the evaluation score was out of (10) points per skill. The performance was assessed by indirect observation using a CD-based skill performance distribution to the referees. The final score was extracted by deleting the highest and lowest scores, then calculating the sum of the two remaining scores and dividing it by (2) to find the arithmetic mean of the referees' scores.

Main experiment

The researchers implemented the main experience on Sunday, March 15, 2026 on (10) freshmen female students (section A) in the College of Physical Education and Sports Sciences for Women. The cameras were mounted on fixed supports 4.55 meters apart and 1.35 meters high on the vaulting platform for both the front and side cameras, and the camera speed was set to 120 frames per second. Before the test began, the researchers provided a detailed explanation of the procedure.

Table 3. Means, standard deviations, median, and skewness coefficient for the explosive power of the legs (standing long jump and vertical jump) and the vault performance on the horse (straddle and tuck).

Variables	Mean	Median	Standard Deviation	Skewness
Standing Long Jump Test	179.30	170	19.500	0.525
Vertical Jump Test	2.276	2.35	0.114	1.688
Vault Performance (Straddle)	5.90	6.00	1.853	0.998
Vault Performance (Tuck)	6.40	7.00	1.647	0.993

Table 4. Shows the means, standard deviations and skewness coefficient for the vault performance on the horse (straddle - tuck) and the biomechanical variables.

Variables	Mean	Median	Standard Deviation	Skewness
Vault Performance (Straddle)	5.90	6.00	1.853	0.998
Take-off Time	0.262	0.23	0.027	0.137
Push-off Time	0.163	0.14	0.017	0.036
Instant of Take-off	65.570	66.70	1.647	1.047
Ankle Joint Angle	134.910	132.50	1.552	0.351
Knee Joint Angle	145.280	143.70	1.418	0.579
Trunk Inclination Angle	54.66	54.60	1.341	0.188
Height of the Center of Mass	108.37	108.12	1.210	1.030
Maximum Flight Height	146.65	148.02	1.634	0.149
Vertical Velocity	2.69	2.81	0.152	1.051
Vault Performance (Tuck)	6.40	7.00	1.647	0.993
Take-off Time	0.292	0.26	0.029	0.140
Push-off Time	0.180	0.17	0.018	0.038
Instant of Take-off	66.870	67.80	1.657	1.057
Ankle Joint Angle	135.811	133.50	1.454	0.324
Knee Joint Angle	146.432	146.70	1.425	0.554
Trunk Inclination Angle	60.66	60.60	1.541	0.268
Height of the Center of Mass	106.37	106.12	1.110	1.060
Maximum Flight Height	144.65	144.02	1.524	0.135
Vertical Velocity	2.89	2.93	0.132	1.043

Statistical analysis

The SPSS statistical package was used to statistically process the results.

3. Results

As shown in Table 3, the results showed that the mean for the standing long jump test was (179.30), while it was (2.276) for the vertical jump. The average skill performance was (5.90) for the straddle vault and (6.40) for the tuck vault, with values of the skewness coefficient ranging between (0.525–1.688), which are within the statistically acceptable limits, indicating the moderation of the data distribution and the possibility of relying on it in the analysis.

As presented in Table 4, the results showed that the means, standard deviations, and skewness coefficient for the skill performance score (straddle vault and tuck vault) on the vaulting platform, as well as the biomechanical variables associated with the take-off phase for both skills, were similar in skewness coefficient values for most of the variables, ranging between (0.036–1.060), which indicates the normality of the data distribution and the possibility of relying on it in the analysis.

The results showed a significant correlation between the straddle and tuck vaults and the muscular strength of the legs.

The results showed that the correlation between the straddle vault and some biomechanical variables was significant for some variables, while it was not significant for others.

The results showed that the correlation between the tuck vault and some biomechanical variables was significant for some variables, while it was not significant for others.

4. Discussion

Table 5 shows that there is a significant correlation between the performance of the jumping stroke and the standing broad jump test, indicating that the explosive power of the legs contributes to improving skill performance. This is because this force is the primary factor in generating forward and vertical thrust, which helps to raise the body's center of mass and achieve a suitable trajectory during take-off, thus positively impacting performance quality. Sands et al. (2016) confirm that leg muscle strength is one of the most important elements and basic determinants in vaulting performance skills in gymnastics.

Table 5. Shows the correlation between vaulting performance (straddle and tuck) and leg muscular strength.

Variables	Mean	Standard Deviation	R	Sig.	Significance
Vault Performance (Straddle)	5.90	1.853			
Standing Long Jump Test	179.30	19.500	0.453	0.026	Significant
Vertical Jump Test	2.276	0.114	0.436	0.034	Significant
Vault Performance (Tuck)	6.40	1.647			
Standing Long Jump Test	179.30	19.500	0.556	0.028	Significant
Vertical Jump Test	2.276	0.114	0.946	0.049	Significant

Table 6. Shows the correlation between the straddle vault performance of the jump and the biomechanical variables of the take-off phase.

Variables	Mean	Standard Deviation	R	Sig	Significance
Vault Performance (Straddle)	5.90	1.853			
Take-off Time	0.262	0.027	0.426	0.219	Not-significant
Push-off Time	0.163	0.017	0.579	0.074	Significant
Instant of Take-off	65.570	1.647	0.813	0.086	Significant
Ankle Joint Angle	134.910	1.552	0.725	0.128	Not significant
Knee Joint Angle	145.280	1.418	0.094	0.797	Not significant
Trunk Inclination Angle	54.66	1.341	0.579	0.079	Significant
Height of the Center of Mass	108.37	1.210	0.654	0.005	Significant
Maximum Flight Height	146.65	1.634	0.644	0.016	Significant
Vertical Velocity	2.69	0.152	0.643	0.045	Significant

Moreover, a significant relationship emerged between the performance of the straddle vault and the vertical jump test, indicating the importance of producing force in a vertical direction in improving height and take-off time. This is consistent with what Prasas et al. (2018) indicated, that developing muscular power contributes to improving the motor characteristics associated with technical performance in gymnastics devices.

In the vaulting event, a significant correlation emerged between performance and the broad jump test. This underscores the importance of horizontal force during takeoff, as it contributes to providing the necessary momentum to complete the skill. This aligns with the findings of some researchers (Takei, 2015), who stated that balance between the horizontal and vertical components is essential in the vaulting performance. The correlation value between the tuck vault and the vertical jump test was (0.946), which is a high value. Razzaq et al. (2019) pointed out that "Special strength training has a direct impact on the speed of motor performance, especially in the approach and take-off phases, due to its crucial role in generating the instantaneous strength needed to cross the vaulting platform and achieve optimal skill performance."

This indicates that this skill relies heavily on explosive power, due to the need for great speed in bringing the body together and controlling it during the take-off, which requires producing a large force in a short time, as confirmed by Kwon et al. (2019). The results in Table 6 show that there is no significant relationship between the straddle vault performance and the take-off time (0.426), which indicates that the take-off time itself is not a decisive factor in determining the quality of performance.

The researchers believe that performance efficiency in vaulting performance depends on the quality of the thrust, not just its duration. This aligns with what Irwin and Kerwin (2009) indicated, namely that performance effectiveness in vaulting depends on the characteristics of the thrust, not its duration. A significant relationship emerged between performance and thrust time (0.579), indicating the importance of this stage in converting horizontal speed to vertical speed because it contributes to determining the height of the center of mass and take-off time.

The push-off phase is one of the most important performance phases in vaulting performance (Takei, 2015). The same table shows a significant relationship between performance and launch time (0.813), which indicates that the timing of the hand contact plays an important role in determining the movement path. The results of Bradshaw and Hume (2012) confirmed that the appropriate timing of the push phase before the vaulting helps to achieve the best launch angle. Concerning the ankle joint angle and the knee joint angle, no significant relationships were found. This can be attributed to the fact that the research sample lacks sufficient experience in coordinating body parts. It can also be added that novice students may rely on (general thrust) without achieving (ideal angular coordination) like experienced ones.

In contrast, a significant relationship was shown between performance and trunk tilt angle, indicating the importance of trunk position in guiding

Table 7. Shows the correlation between tuck vault performance of the jump and the biomechanical variables of the take-off phase.

Variables	Mean	Standard Deviation	R	Sig	Significance
Vault Performance (Tuck)	6.40	1.647			
Take-off Time	0.292	0.029	0.605	0.064	Significant
Push-off Time	0.180	0.018	0.374	0.287	Not significant
Instant of Take-off	66.870	1.657	0.763	0.010	Significant
Ankle Joint Angle	135.811	1.454	0.829	0.003	Significant
Knee Joint Angle	146.432	1.425	0.159	0.667	Not significant
Trunk Inclination Angle	60.66	1.541	0.702	0.031	Significant
Height of the Center of Mass	106.37	1.110	0.024	0.947	Not significant
Maximum Flight Height	144.65	1.524	0.136	0.708	Not significant
Vertical Velocity	2.89	0.132	0.068	0.851	Not significant

movement during take-off. The appropriate tilt contributes to achieving a balance between the horizontal and vertical directions (Takei, 2015). Moreover, the results revealed significant relationships between the height of the body's center of mass, the maximum altitude of flight, and also with vertical speed; which indicates that these variables are important indicators in determining performance quality, as they reflect the efficiency of force conversion into kinetic achievement.

Sands et al. (2016) agreed that the height of the center of mass and vertical speed are among the most important factors and determinants in vaulting performance skills in gymnastics. Therefore, increasing the vertical speed at the moment of take-off directly leads to an increase in flight time according to the laws of projectile motion, which gives the student enough time to perform the main part of the skill (opening or closing).

Moreover, Table 7 showed a significant relationship between the vaulting performance and the take-off, which confirms the importance of timing in this skill becasue the vaulting performance requires precise coordination between the stages of movement.

There is also a significant relationship between performance and take-off time, which indicates the importance of the moment of take from the vault in determining the success of the performance. Bradshaw and Hume (2012) indicates that proper timing influences achieving the correct movement position. There is also a significant relationship between ankle joint angle and trunk tilt angle, demonstrating the importance of terminal thrust in guiding the body during take-off. This is consistent with what Takei (2015) stated, that the ankle joint contributes to giving the final push, as it is the last part of the kinetic chain of the body that participates in producing force when taking off.

He also emphasized the importance of torso position in achieving balance and control during performance. No significant relationship was found with thrust time or knee angle with the center of mass height, maximum height, and vertical speed.

This can be explained by the fact that the skill of tuck vault skill depends more on the variables of timing and motor coordination, which explains the emergence of significant relationships with take-off time, launch time, ankle angles and trunk tilt due to their direct connection to the organization of the motor rhythm and the body's trajectory.

On the other hand, no significant relationships were found with other biomechanical variables since they do not represent a decisive factor in distinguishing performance levels in this skill, which does not require extreme mechanical demands compared to the straddle vault. This aligns with Kwon et al. (2019), who emphasize that performance in the tuck vault depends not primarily on height, but rather on motor control and timing.

5. Conclusions

Through the discussion of the results, the researchers came up with the following conclusions:

1- The muscular strength of the legs plays a key role in improving performance levels in the skills of jumping on the vaulting platform (straddle and tuck).
2- Successful open vaulting performance is connected to biomechanical variables related to the take-off and launch phases, particularly those affecting the height of the body's center of mass and flight time.
3- Performance in tuck vaulting depends more on biomechanical timing and precise control of body position during the take-off, compared to relying on altitude variables.
4- Some biomechanical variables (e.g., knee angle) actually have little effect on performance. Therefore, it is more important for motor coordination and integration of body parts are more important than individual angular values.
5- The variables affecting performance vary according to the skill type (straddle and tuck),

indicating the particular biomechanical needs of each skill.

6- A higher center of mass and vertical speed contribute to better performance quality in open vaulting. They are indicative of the effectiveness of converting force into effective motor performance.

6. Recommendations

1- Both educational and training programs should focus on leg muscular strength, connecting it to the specific skills required during the take-off phase on the vault.

2- The correct application of joint angles and movement timing in the take-off phase should also be taught to students, as it directly affects performance quality.

3- Biomechanical analysis should be used as a tool to evaluate performance and identify errors, particularly in gymnastics vaulting skills.Future studies should examine other variables (such as neuromuscular coordination or speed-strength) and their relationship to skill performance on various gymnastics vaulting platform.

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 study was approved by the Scientific Committee of the College of Physical Education and Sports Sciences for Women, University of Baghdad, Iraq, on (22/2/2026).

Author's contributions

All contributions to this study were carried out by the researchers. **Intisar Kadhim Abdul Kareem** conducted the study procedures, collected and organized the data, participated in the implementation of the experimental program, and contributed to drafting the manuscript. **Zina Abdel Salam** developed the research idea, designed the study, supervised the research procedures, interpreted the results, and reviewed and finalized the manuscript. **Zubaidah Salah Hadi** contributed to data analysis, manuscript revision, and final approval of the manuscript. **Özgür Eken** contributed to study design consultation, methodological refinement, and critical revision of the manuscript.

The study also benefited from the assistance of a number of experts: **Lect. Dr. Zubaidah Salah Hadi** (Statistics), **Prof Dr. Huda Shihab** (Revision), and **Asst. Lect. Inam Al-Azzawi** (Translation).

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Data availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

References

Barreto, J., Peixoto, C., Cabral, S., Williams, A., Casanova, F., & Veloso, A. (2021). Concurrent validation of 3D joint angles during gymnastics techniques using inertial measurement units. *Electronics*, *10*(11), 1251. https://doi.org/10.3390/electronics10111251.

Bradshaw, E. J., & Hume, P. A. (2012). The reliability and variability of day-to-day vaulting performance in artistic gymnastics. *Sports Biomechanics*, *11*(3), 324–341. https://doi.org/10.1080/14763141.2012.725140.

Čuk, I., & Karácsony, I. (2004). *Vault: Methods, ideas, curiosities, history*. University of Ljubljana, Faculty of Sport, p. 143.

Hiley, M. J., Jackson, M. I., & Yeadon, M. R. (2015). Optimal technique for maximal forward rotating vaults in men's gymnastics. *Human Movement Science*, 42, 117–131. https://doi.org/10.1016/j.humov.2015.05.006.

Irwin, G., & Kerwin, D. G. (2009). Muscle activation and performance in gymnastics vaulting. *Sports Biomechanics*, *8*(2), 114–128. https://doi.org/10.1080/14763140902745057.

Kochanowicz, A., Kochanowicz, K., Niespodziński, B., Mieszkowski, J., Aschenbrenner, P., Bielec, G., & Szark-Eckardt, M. (2016). Maximal power of the lower limbs of youth gymnasts and biomechanical indicators of the forward handspring vault versus the sports result. *Journal of Human Kinetics*, *53*, 33–40. https://doi.org/10.1515/hukin-2016-0008.

Kwon, Y. H., Fortney, V. L., & Shin, I. S. (2019). 3D analysis of gymnastics vault techniques and performance. *Journal of Sports Sciences*, *37*(5), 523–531. https://doi.org/10.1080/02640414.2018.1510466.

Musa, M. T. (2014). *The effects of speed–strength exercises on the balance of strength between agonist and antagonist muscles and their impact on selected physical attributes and the performance phase of the 100 m sprint for youth* (Unpublished master's thesis). University of Al-Qadisiyah, Iraq.

Prassas, S., Kwon, Y. H., & Sands, W. A. (2018). *Routledge handbook of biomechanics*. Routledge. p. 120–125.

Razzaq, Z.A.S.A, Mutashar, S.A., & Al Shammari, A.R. (2019). Analysis of some variable biomechanical to triple jump world champions for the world championships in 2013. *Journal of Human Sport and Exercise*, *14*(4proc), S450–S457. https://doi.org/10.14198/jhse.2019.14.Proc4.03

Razzaq, Z.A.S.A., Almujamay, A.S., & Almojamay, H.A.M. (2019). The effect of special force training on the development of biomechanical variables for running raising awareness during the performance on the jumping table. *Journal of Human Sport and Exercise*, *14*(4proc), S458–S468. https://doi.org/10.14198/jhse.2019.14.Proc4.04

Sands, W. A., *et al.* (2016). Biomechanical aspects of gymnastics vault performance. *USA Gymnastics Journal, 24*(1), 12–20.

Schärer, C., Haller, N., Taube, W., & Hübner, K. (2019). Physical determinants of vault performance and their age-related differences across male junior and elite top-level gymnasts. *PLOS ONE*, *14*(12), e0225975. https://doi.org/10.1371/journal.pone.0225975

Takei, Y. (2015). Techniques used in high-scoring vaults in men's artistic gymnastics. *Sports Biomechanics*, *14*(2), 145–160. https://doi.org/10.1080/14763141.2015.1029.

القوة العضلية والمديات الزاوية لبعض مفاصل الجسم في مرحلة الارتقاء وعلاقته بأداء القفز على منصة القفز

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المستخلص:

تعد رياضة الجمناستك الفني من الرياضات التي تتطلب مستوى عالي من التكامل بين القدرات البدنية والمهارية والميكانيكية حيث يعتمد نجاح الأداء فيها على قدرة اللاعب في التحكم الدقيق بحركات أجزاء الجسم وتنسيقها خلال مراحل الأداء. ويعد جهاز منصة القفز من الأجهزة التي تتطلب مقدار كبير من القوة والسرعة خلال وخلال فترة زمنية قصيره نسبيا، ان التنفيذ الأداء الفني لفعالية القفز يمر بعدة مراحل أساسية تبدأ بمرحلة الاقتراب ثم الارتقاء من منصة القفز وتليها مرحلتا الطيران الأول والثاني ثم الهبوط. وهدف البحث التعرف على العلاقة بين القوة العضلية والمديات الزاوية لمفاصل الجسم في مرحلة الارتقاء وبين الأداء في القفز على جهاز منصة القفز. وتم استخدام المنهج الوصفي على عينة اختيرت بالطريقة العمدية قوامها (10) طالبات من المرحلة الاولى لكلية التربية البدنية وعلوم الرياضة للبنات. أظهرت النتائج ان الوسط الحسابي لأداء القفز من الحصان فتحا (5.90) وانحراف معياري (1.853) أما ارتفاع مركز كتلة الجسم بلغت قيمة الوسط الحسابي (108.37) وبانحراف معياري (1.210) وكان قيمة معامل الارتباط (0.654) وهذا يدل على كفاءة تحويل القوة إلى إنجاز حركي فعال وخرجت الباحثات بعدة توصيات منها ضرورة التركيز في البرامج التعليمية والتدريبية على تطوير القوة العضلية للرجلين، مع ربطها بالتطبيقات المهارية الخاصة بمرحلة الارتقاء في جهاز منصة القفز.

الكلمات المفتاحية: القوة العضلية، المدى الزاوي للمفاصل، مرحلة الارتقاء، أداء القفز على منصة القفز.