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Biomechanical evaluation of physical and sports tests: the standing long jump as a stability model

ABSTRACT

This study aimed to analyze the effectiveness of the biomechanical approach in the study of sports movements by applying mechanical laws to training and the evaluation of athletes' technical-motor performance. The goal was to understand the factors that determine movement efficiency and optimize the technical execution methods associated with a high level of athletic performance. The methodology employed was an experimental design with a quantitative approach, developed through the formation of two groups: an experimental group and a control group, each composed of four athletes. The experimental group underwent a specialized training program based on biomechanical principles, accompanied by systematic evaluations based on this same scientific approach. The control group, on the other hand, followed conventional training and evaluation methods. Data collection was carried out through physical and technical tests, as well as the analysis of kinematic and dynamic variables relevant to athletic performance. The results showed significant improvements in the technical-motor performance of the experimental group compared to the control group, confirming the validity of the hypotheses. The athletes who underwent the biomechanical program showed greater efficiency in movement execution, optimization of physical effort, and improved stability and coordination. In conclusion, the study demonstrated that training and evaluation based on biomechanical principles are essential tools for improving athletic performance.

Keywords: Evaluation, physical tests, biomechanics

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Evaluación biomecánica de pruebas físicas y deportivas: el salto de longitud en pie como modelo de estabilidad

RESUMEN

El presente estudio tuvo como objetivo analizar la eficacia del enfoque biomecánico en el estudio de los movimientos deportivos, mediante la aplicación de las leyes mecánicas al entrenamiento y a la evaluación del rendimiento técnico-motor de los atletas. Se busco comprender los factores que determinan la eficiencia del movimiento y optimizar los métodos de ejecución técnica asociados a un alto nivel de desempeño deportivo. La metodología empleada correspondió a un diseño experimental con enfoque cuantitativo, desarrollado a través de la conformación de dos grupos: un grupo experimental y un grupo de control, integrados cada uno por cuatro atletas. Al grupo experimental se le aplicó un programa de entrenamiento especializado fundamentado en principios biomecánicos, acompañado de evaluaciones sistemáticas basadas en este mismo enfoque científico. Por su parte, el grupo de control siguió métodos de entrenamiento y evaluación convencionales. La recopilación de datos se realizó mediante pruebas físicas y técnicas, así como el análisis de variables cinemáticas y dinámicas relevantes para el rendimiento deportivo. Los resultados evidenciaron mejoras significativas en el rendimiento técnico-motor del grupo experimental en comparación con el grupo de control, confirmando la validez de las hipótesis planteadas. Los atletas sometidos al programa biomecánico mostraron mayor eficiencia en la ejecución de los movimientos, optimización del esfuerzo físico y mejor control de la estabilidad y coordinación. En conclusión, el estudio demostró que el entrenamiento y la evaluación basados en fundamentos biomecánicos constituyen herramientas esenciales para mejorar el rendimiento deportivo.

Palabras clave: Evaluación, pruebas físicas, biomecánica

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Avaliação biomecânica de ensaios físicos e desportivos: o salto em comprimento parado como modelo de estabilidade

RESUMO

Este estudo teve como objetivo analisar a eficácia da abordagem biomecânica no estudo dos movimentos desportivos, aplicando leis mecânicas ao treino e à avaliação do desempenho técnico-motor de atletas. O objetivo foi compreender os fatores que determinam a eficiência do movimento e otimizar os métodos de execução técnica associados a um elevado nível de desempenho atlético. A metodologia empregue foi um desenho experimental com uma abordagem quantitativa, desenvolvido através da formação de dois grupos: um grupo experimental e um grupo de controlo, cada um composto por quatro atletas. O grupo experimental foi sujeito a um programa de formação especializado baseado em princípios biomecânicos, acompanhado de avaliações sistemáticas baseadas nesta mesma abordagem científica. O grupo de controlo, por sua vez, seguiu os métodos convencionais de treino e avaliação. A recolha de dados foi realizada através de testes físicos e técnicos, bem como pela análise de variáveis cinemáticas e dinâmicas relevantes para o desempenho atlético. Os resultados mostraram melhorias significativas no desempenho técnico-motor do grupo experimental em comparação com o grupo controlo, confirmando a validade das hipóteses. Os atletas que participaram no programa biomecânico apresentaram maior eficiência na execução dos movimentos, otimização do esforço físico e melhoria da estabilidade e coordenação. Em conclusão, o estudo demonstrou que o treino e a avaliação baseados em princípios biomecânicos são ferramentas essenciais para melhorar o desempenho atlético.

Palavras-chave: Avaliação, testes físicos, biomecânica

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INTRODUCTION

Biomechanics is a science concerned with the quantitative and qualitative analysis of human movements to enhance their efficiency. This is achieved by utilizing the technological tools recently available in sports clubs, particularly for collecting data on performance, including biomechanical indicators that the naked eye cannot accurately detect. Identifying the deficiencies in exceptional performance allows for the development of training programs to address these issues and improve overall effectiveness.

Since the performance of sports activities is now subject to precise mechanical laws that play a crucial role in evaluating distinctive motion paths, the biomechanical variables become essential when performing the required motor tasks. These tasks must be executed with specific mechanical characteristics, avoiding undesirable angles and minimizing significant reductions in speed, distance, energy, and momentum between movement phases. Biomechanical analysis helps apply mechanical conditions to the skill or activity being studied by diagnosing weaknesses, comparing them to optimal performance, and strengthening areas of excellence through detailed examination and comparison.

The central research question arises: To what extent does our evaluation of motor performance remain limited to the final outcome without scrutinizing its components? This leads to the following inquiry: Are there statistically significant differences between the pre- and post-measurement results in performance levels for the experimental and control groups in physical fitness tests?

The sub-questions derived from the main research question are:

Are there no statistically significant differences between the pre- and post-measurement results in physical fitness tests for the control group using conventional training methods?

Are there statistically significant differences between the pre- and post-measurement results in physical fitness tests for the experimental group using the biomechanical approach?

The corresponding hypotheses suggest that:

There are no statistically significant differences between the pre- and post-measurements in the physical fitness test results for the control group using conventional methods.

There are statistically significant differences between the pre- and post-measurements in the physical fitness test results for the experimental group using the biomechanical approach. The general hypothesis posits that there are statistically significant differences between the pre- and post-measurement results in performance levels for both the experimental and control groups in physical fitness tests.

The significance of this study lies in addressing a research gap where technical methods used to learn and evaluate optimal performance have received limited local attention due to the precision and complexity involved, especially when compared to international standards. This study aims to develop movement solutions to identify and correct performance errors while aligning with specific biomechanical requirements. By designing and implementing performance evaluation tests based on biomechanical criteria, the study examines the relationship between biomechanical variables and athletic performance. The ultimate goal is to highlight the importance of this scientific dimension and its application in developing training programs across various sports disciplines and improving performance evaluation both quantitatively and qualitatively.

The experimental method was adopted as it is suitable for the nature of this study.

Spatial and Temporal Scope:

The field research, including pre- and post-tests for both groups, was conducted in the same sports field. The practical work extended from August 7, 2023, to September 12, 2024.

Tools and Data Collection Methods:

Arabic and foreign sources and references.

Testing and measurement using specialized tools.

Technical observation and experimentation with research devices.

Acer Pentium 04 electronic computer.

Four (4) high-quality video recording cameras.

Analytical software: Kinovea and Avistap for motion analysis, and Total Video Converter 3.73 for video processing.

Principles and Characteristics of Effective Evaluation:

Effective evaluation must exhibit specific characteristics to perform its functions efficiently, including:

Alignment with Objectives: Evaluation should be closely linked to the specified objectives and emphasize their accurate purposes.

Comprehensiveness: The evaluation program should cover all aspects of experience, including knowledge, skills, attitudes, and thinking methods.

Continuity: Evaluation is an ongoing process with diagnostic functions, involving planning, implementation, and follow-up.

Integration and Diversity: Evaluation methods should be diverse, interconnected, and integrated for comprehensive assessment.

Scientific Basis: Evaluation should rely on scientifically standardized tests to ensure validity, reliability, and objectivity.

Validity: The evaluation tools must accurately measure what they are intended to assess.

Reliability: If the same test is repeated on the same individuals after a certain period, it should yield similar results.

Discrimination: Evaluation tools should distinguish individual differences and reveal specific characteristics to identify strengths and weaknesses.

Democratic Approach: Evaluation should adopt democratic methods, ensuring the active and positive participation of individuals.

Behavioral Focus: Evaluation should focus on human behavior, as it helps individuals understand their performance level and fosters positive relationships between trainers and trainees, promoting self-confidence.

Interpretability: Evaluation results should be interpretable, providing diagnostic meaning that facilitates their use in improving the individual’s training status.

Efficiency: Evaluation should be economical in terms of time, effort, and cost.

Collaborative Process: Evaluation should involve the athlete, coach, physician, and administrative personnel.

Inclusive Participation: Evaluation should not be limited to the instructor alone but should include all individuals concerned with the athlete’s progress (Rodin & Rodin, 1972)

The Most Important Software Used in Motion Analysis:

As is widely known, computer software has diversified to such an extent that defining its boundaries has become challenging. The purposes for using this software have also expanded, and although multiple programs may serve the same function, we aim to present here the most essential software used in motion analysis while highlighting the specific objectives of each program.

It is important to emphasize that there are numerous software programs capable of performing similar tasks, and the only distinguishing factor lies in our familiarity with using them. Among the most prominent motion analysis programs are:

1. **KINOVEA Software:**

This software is used to analyze all sports skills by providing scientific data. Similar to Dartfish, it functions as a video player capable of displaying slow-motion playback. It supports specific features for monitoring, analyzing, and describing athletes' performance.

Key functionalities include:

Studying sports movements and providing technical feedback by recording and annotating performance.

Image processing and the ability to view multiple videos simultaneously.

Comparing different attempts of the athlete to identify strengths and weaknesses.

Extracting analytical data through comprehensive reports, facilitating the study of relationships between variables under investigation (Aboul-Ezz, 2023)

Figure 1

Depicting key aspects tracked and analyzed using KINOVEA software.

- AVISTAP Program:

AVISTAP is one of the most powerful programs for studying motion through sequential imaging due to its extensive capabilities. The program enables the calculation of velocity and acceleration values at every moment and allows for:

Vector representation of instantaneous velocity and acceleration.

Plotting curves for the trajectory, velocity, and acceleration over time.

Detailed motion analysis by extracting accurate values for various kinematic variables.

Table 1.

Key Variables Extracted by AVISTAP Program

T	X	Y	Vx	Vy	V	Ax	Ay	a	O	R	w
S	M	M	m/s	m/s	m/s	m/s²	m/s²	m/s²	rad	m	rad/s
Time	Abscissa	Ordinate	X-component	Y-component	Velocity	X-acceleration	Y-acceleration	Acceleration	Angular position	Radial position	Angular velocity

- Physical Test (Standing Long Jump Test):

The standing long jump test is a standard physical fitness assessment used to measure explosive power (muscular strength of the legs). The test aims to evaluate the development of explosive capacity (a combination of strength and speed) in the muscles operating the lower limb joints. This capacity is crucial for improving vertical jump distance, which directly impacts take-off force and horizontal motion required for optimal performance.

- Equipment Used:

A suitable area measuring 1.50 m in width and 3.50 m in length, which must be flat and free of obstacles.

A measuring tape and a marker pen (e.g., magic marker).

- Procedure:

The jumping area is marked with parallel lines (5 cm wide), spaced at 1-meter intervals from the take-off line.

Each meter is further divided by additional parallel lines spaced 5 cm apart.

- Test Description:

The participant stands behind the starting line with feet slightly apart and parallel, ensuring the toes touch the starting line externally.

The participant swings their arms backward, bends their knees, and leans slightly forward.

The participant then jumps forward as far as possible by extending the knees, pushing off with both feet, and swinging the arms forward for added momentum.

- Performance Conditions:

The test must be conducted on a wooden surface to allow for adequate propulsion.

The jump must be performed using both feet simultaneously.

Warm-up is allowed before the test.

Participants should avoid falling backward upon landing.

Arm swings should be directed forward and upward to assist with propulsion.

The test may be performed while wearing sports shoes (Lake, 2000)

Table 2.

Classification of Performance Levels for the Standing Long Jump Test

Classification	Excellent	Very Good	Above Average	Average	Below Average	Weak	Very Weak
Males (cm)	> 250	241-250	201-240	161-200	140-160	21-139	< 121

Figure 2

Camera positions for tracking the fieldwork process of the standing long jump test and monitoring the target variable.

Figure 3

An illustrative diagram showing the positions of the two cameras for the standing long jump test.

Methods for Calculating and Extracting Certain Values:

Momentum and Kinetic Energy:

- **Momentum (P)** = Mass × Velocity (average until the second-to-last step)
- **Kinetic Energy (KE)** = ½ Mass × Velocity²
- **P_1** = Mass × $Velocity_1$ (velocity at the moment of impact with the take-off board)
- **P_2** = Mass × $Velocity_2$ (resultant horizontal and vertical velocity at the moment of take-off)
- **ΔP** = $P_2 - P_1$ (change in momentum during the take-off phase)

- Angular Velocity of Body Parts:

Using the analytical software AviStep, which provides linear and angular velocities, angles of body parts at each moment, and horizontal and vertical velocities. The calculations were conducted as follows:

- Angular Velocity of the Arm:

  Determined by tracking its movement during the take-off moment, placing virtual points on the jumper's elbow joint, and calculating the average of these values.
- Angular Velocity of the Free or Supporting Leg:

  Measured by placing a virtual point on the ankle joint during its motion and calculating the average of these values.
- Angular Velocity of the Hip:

  Calculated by placing a virtual point on the hip joint and determining the average of these values.

- Push-Off Force:

  Calculated using the formula:

$$F = (P_1 / D_1 + g) + (P_2 / D_2 + g)$$

Where:

- **D_1** is the displacement of the virtual center of gravity point at the hip joint level, from the moment of impact with the take-off board to the absorption phase.
- **D_2** is the displacement of the virtual point at the hip joint level of the center of gravity, from the absorption phase to the push-off moment.
- **P_1** is the linear velocity of the center of gravity at the moment of impact.
- **P_2** is the resultant linear velocity (horizontal and vertical) of the center of gravity at the push-off moment.
- **g** = 9.81 m/s² (Parslew et al., 2018)

Figure 4

for Tracking the Center of Gravity Displacement to Calculate Push-Off Force

Practical Section:

Tabulation and Sorting of Test Results for Both Groups

Table 3

Anthropometric Measurements of the Experimental and Control Groups

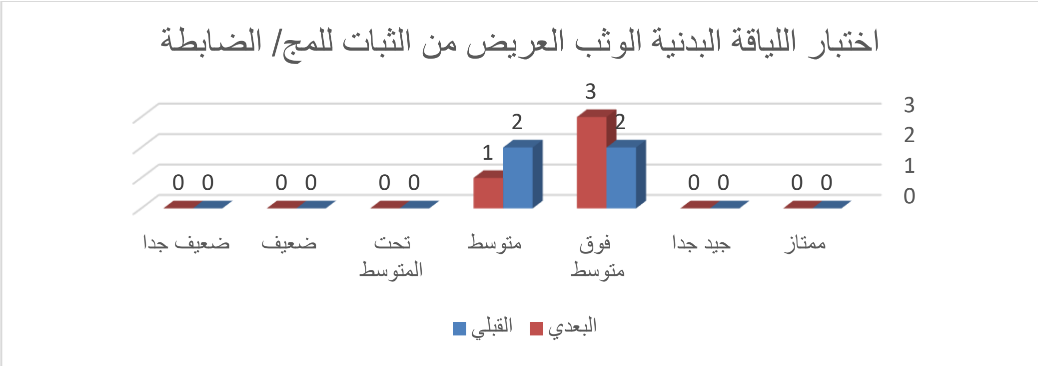
Experimental Group	Athlete	Weight (kg)	Height (m)	Control Group	Athlete	Weight (kg)	Total Height (m)
	01	65	1.74		01	71	1.765
	02	68	1.75		02	64	1.74
	03	67	1.75		03	66.8	1.75
	04	68	1.78		04	67.4	1.77
Mean (s)		67.0	1.755	**Mean (s)**		67.3	1.7562
Standard Deviation (x)		1.41	1.732	**Standard Deviation (x)**		2.87	1.377

Pre- and Post-Tests for Both Groups:

Control Group:

Figure 5

for the Pre- and Post-Physical Fitness Test of the Control Group (Standing Broad Jump) According to Performance Level



ANALYSIS OF RECORDED RESULTS

After implementing the second phase of the training program for the control group, the post-test was conducted to evaluate the physical attribute characteristic of this critical stage. The bar chart above reflects the improvement in explosive strength through the standing broad jump test for the group. The findings indicate the following:

Although there was an improvement when comparing the mean of the achieved values to the pre-test results, the performance levels of the group members were distributed as follows:

Before the training program:

50% (2 athletes) were at the average level.

50% (2 athletes) were at the above-average level.

After the training program:

One athlete moved from the average to the above-average level.

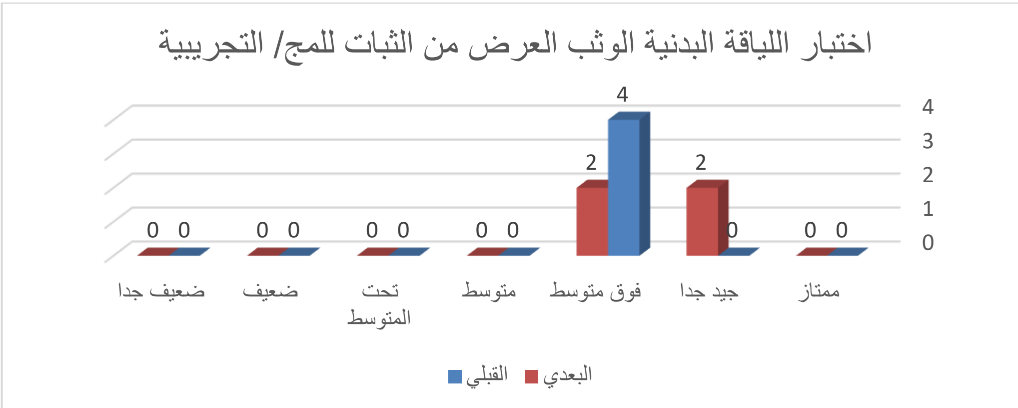
37.5% (1 athlete) remained at the average level.

62.5% (3 athletes) achieved the above-average level.

Experimental Group:

Figure 6

Bar Charts for Pre- and Post-Physical Fitness Tests of the Experimental Group (Standing Long Jump) According to Digital Performance Levels:



Based on the results of the post-test for the experimental group, there is clear evidence of improvement in explosive strength through the standing long jump test. Compared to the pre-test results, where (4) participants (100%) were classified at an above-average level, the post-test following the implementation of the proposed training program based on biomechanical variables showed that (2) participants (50%) moved from the above-average level to the very good level, while (2) participants (50%) remained at the above-average level. This indicates a significant improvement compared to the pre-test results and the control group’s performance. This improvement is attributed to the effectiveness of the specialized training units in this area.

2-1 Biomechanical Analysis of the Pre- and Post-Test for the Experimental Group:

Table 4

Results of the Pre-Test for Physical Fitness (Standing Long Jump) for the Experimental Group According to Biomechanical Variables

No.	Variables	Measurement Unit	1	2	3	4	Mean ($\bar{x}$)	Std. Dev. (s)
1	Push Moment Velocity	m/s	3.92	3.59	3.61	3.66	3.69	0.15
2	Push Duration	s	33	35	34	31	33.25	1.70
3	Push Force	Newton	772	728	711	802	753.25	41.43
4	Arm Angular Velocity	deg/s	212.4	301.3	222.4	297	258.27	47.40
5	Knee Angle (Max Flexion)	Degree	105	109	114	96	106.00	7.61
6	Distance	cm	203	220	205	231	214.75	13.22

Table 5

Results of the Post-Test for Physical Fitness (Standing Long Jump) for the Experimental Group According to Biomechanical Variables

No.	Variables	Measurement Unit	1	2	3	4	Mean (x̄)	Std. Dev. (s)
1	Push Moment Velocity	m/s	4.17	4.23	4.07	4.7	4.29	0.28
2	Push Duration	s	27	28	30	25	27.50	2.08
3	Push Force	Newton	994	1057	908	1273	1058	155.80
4	Arm Angular Velocity	deg/s	311.4	323.6	296.1	334.2	316.32	16.38
5	Knee Angle (Max Flexion)	Degree	121	129	113	136	124.75	9.94
6	Distance	cm	247	238	224	246	238.75	10.62

Table 6

Means, Standard Deviations, and (t) Value with (sig) Significance for Biomechanical Variables in the Post-Test for the Experimental Group (Standing Long Jump)

No.	Variables	Experimental Group	Calculated (t)	Sig (p-value)	df	Critical Value	Statistical Decision
		Pre-Test	Post-Test				
		Mean (x̄)	SD (s)	Mean (x̄)	SD (s)		
1	Push Moment Velocity	3.69	0.15	4.29	0.28	3.750	0.009
2	Push Duration	33.25	1.70	27.50	2.08	4.271	0.005
3	Push Force	753.25	41.43	1058	155.80	3.781	0.009
4	Arm Angular Velocity	258.27	47.40	316.32	16.38	2.315	0.087
5	Knee Angle (Max Flexion)	106	7.61	124.75	9.94	2.994	0.024
6	Distance	214.75	13.22	238.75	10.62	2.829	0.029

(*) Statistically significant at a 0.05 error level with a degree of freedom (06) and a critical value of (2.447).

The mean and standard deviation for the push moment velocity variable in the pre- and post-tests were (3.69 ± 0.15) and (4.29 ± 0.28), respectively. The calculated (t) value was (3.750), which exceeds the critical value (2.447). The (sig) value of (0.009) is less than (0.05), indicating a statistically significant difference between the pre- and post-test results in favor of the post-test.

Regarding the mean and standard deviation of the pre-test and second interim test for the same group in the physical test of the variable "Push Time," the results were as follows: (33.250, 1.708) for the pre-test and (27.500, 2.082) for the second interim test. The calculated t-value was (4.271), and since the calculated value is greater than the tabulated value (2.447), and when related to the sig value of (0.005), which is less than the significance level of (0.05), this indicates that the difference is statistically significant between the pre- and post-test results for the "Push Time" variable, favoring the post-test.

As for the mean and standard deviation for the pre-test and second interim test of the "Push Force" physical test variable, the results were as follows: (753.250, 41.436) for the pre-test and (1058.000, 155.801) for the second interim test. The calculated t-value was (3.781), and since the calculated value is greater than the tabulated value (2.447), and when related to the sig value of (0.009), which is less than the significance level of (0.05), this indicates that the difference is statistically significant between the pre- and post-test results for the "Push Force" variable, favoring the post-test.

Regarding the mean and standard deviation of the pre-test and second interim test for the "Angular Arm Speed" physical test variable, the results were as follows: (258.275, 47.407) for the pre-test and (316.325, 16.388) for the second interim test. The calculated t-value was (2.315), and since the calculated value is less than the tabulated value (2.447), and when related to the sig value of (0.087), which is greater than the significance level of (0.05), this indicates that the difference is not statistically significant between the pre- and post-test results for the "Angular Arm Speed" variable, favoring the pre-test.

For the mean and standard deviation of the pre-test and second interim test for the "Knee Angle (Maximum Flexion)" physical test variable, the results were as follows: (106.000, 7.616) for the pre-test and (124.750, 9.946) for the second interim test. The calculated t-value was (2.994), and since the calculated value is greater than the tabulated value (2.447), and when related to the sig value of (0.024), which is less than the significance level of (0.05), this indicates that the difference is statistically significant between the pre- and post-test results for the "Knee Angle (Maximum Flexion)" variable, favoring the post-test.

For the mean and standard deviation of the pre-test and second interim test for the "Distance" physical test variable, the results were as follows: (214.750, 13.226) for the pre-test and (238.750, 10.626) for the second interim test. The calculated t-value was (2.829), and since the calculated value is greater than the tabulated value (2.447), and when related to the sig value of (0.029), which is less than the significance level of (0.05), this indicates that the difference is statistically significant between the pre- and post-test results for the "Distance" variable, favoring the post-test.

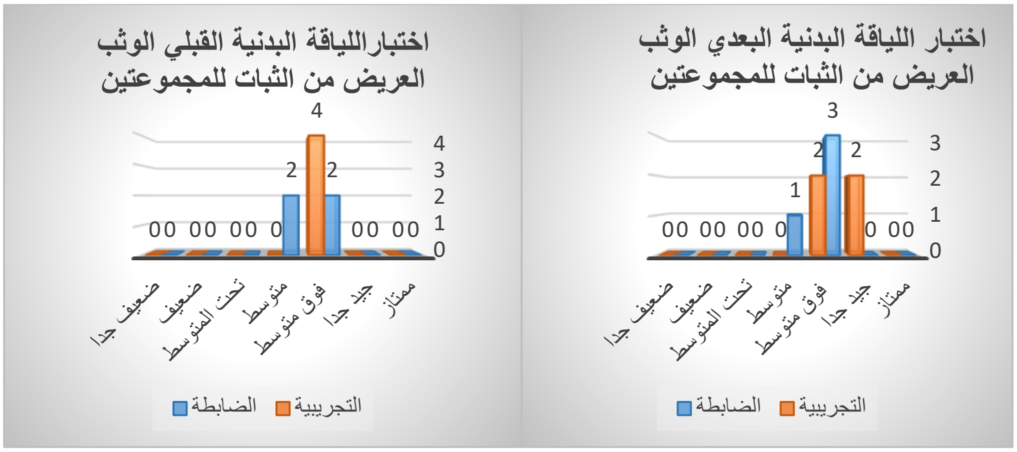
After presenting the results of the physical fitness test for the broad jump from a static position regarding the evaluation of performance for both groups, according to the proposed training program for the experimental group, we did not only focus on the final performance result but also tracked the changes in the biomechanical variables responsible for achieving the final performance. This scientific tracking allowed us to assess the improvements made in the components of performance, based on which we can decisively conclude improvements in the key biomechanical variables involved in the takeoff phase.

Firstly, the "Knee Angle (Maximum Flexion)" during push-off and the "Push Speed" were statistically significant and related to the "Push Time" variable, which indicates the body’s acceleration from rest to the maximum possible distance. This improvement is attributed to the coordination in the transfer of motion between body parts. Moreover, the "Angular Arm Speed" showed some improvement, even though it was not statistically significant. However, its average value improved compared to the pre-test results. This was all due to the "Push Force" variable, which showed statistically significant results in favor of the post-test for the experimental group. This, in turn, affected the "Distance" variable, which was also statistically significant in favor of the post-test.

In the pre-test, the average distance was (214.750 cm), and in the post-test, it was (238.750 cm), representing a significant improvement of (24 cm), much higher than the results recorded by the control group, which showed only a (0.25 cm) difference between the tests. This improvement is attributed to the effective follow-up of the scientific program based on the proposed biomechanical approach for the experimental group, which focused on improving key physical qualities associated with the takeoff phase, including explosive strength and speed-strength in the lower limbs.

Figure 7

for the pre-test and post-test of both groups for the physical fitness test (Broad Jump from a Static Position) according to the performance level in numerical achievement.



After presenting and analyzing the results of the post-test for physical fitness, it is evident that its variables are characterized by accuracy, as the short duration of performance means that any malfunction in one of its biomechanical variables has a direct and significant impact on the final jump performance. Based on this, we did not only track the course and improvement of these variables but also focused on identifying the changes that affected the key variables. The results are shown in the graphs for each group individually, where we aimed to demonstrate the effectiveness of the biomechanical approach in addressing gaps and deficiencies among the individuals in both the pre-test and post-test.

In the pre-test, the experimental group (04) all had above-average levels, while the control group (02) showed above-average levels and (02) at average levels. After implementing the planned biomechanical study, the following changes were recorded in the post-test: the experimental group improved, with (02) participants reaching a very good level and (02) remaining above average. As for the values recorded, we observed good results, unlike the control group, where (03) participants were at above-average levels and (01) at an average level. While there was some improvement in the control group, it was very limited compared to the experimental group, which can be attributed to the effectiveness of the scientific follow-up based on a precise biomechanical approach, ensuring systematic improvement of this physical characteristic in a scientific manner with indicators and biomechanical metrics that proved effective for the experimental sample.

There are no statistically significant differences between the pre-test and post-test measurements for the control group in the performance level of the broad jump based on the applied method.

There are statistically significant differences between the pre-test and post-test measurements for the experimental group in the performance level of the broad jump based on the biomechanical approach.

There are statistically significant differences between the pre-test and post-test results for both the experimental and control groups in the performance level of the broad jump.

CONCLUSION

Through this study, it was shown that training and evaluating sports performance must be based on analysis. It focuses on performance and seeks to study the components and parts of movement in order to refine them for better technique. It is one of the accurate means of understanding the pathway for improvement and development. Additionally, sports analysis is used to solve problems related to learning and training, as it diagnoses and evaluates movements by comparing their parts, timings, and strengths according to specific standards. This helps coaches select the appropriate exercises to ensure that athletes perform movements correctly and create special training and educational conditions to achieve that goal. Regardless of whether the approach is quantitative or qualitative, it involves identifying, studying, and analyzing the movement to provide solutions or answers to the necessary inquiries. To analyze movement scientifically, a set of specific questions must be posed regarding the movement, focusing on the conditions of the movement analysis. These questions can be general or specific. Therefore, the training process must be directed (both scientifically and practically) to pave the way for raising and improving athletic performance by using a scientific approach based on biomechanical movement analysis.

STUDY LIMITATIONS

This study presents certain limitations that should be considered when interpreting the results. First, the small sample size, consisting of eight athletes divided into two groups, limits the generalizability of the findings to broader populations or other sports disciplines. Additionally, the research focused exclusively on the standing long jump as a model for analysis; therefore, the results cannot be directly extrapolated to other motor skills with different biomechanical characteristics. Another limitation is related to the duration of the intervention, which, although sufficient to demonstrate significant improvements, could be extended to analyze long-term effects. Finally, the use of specific biomechanical analysis software, while valid and reliable, depends largely on the accuracy of motion capture and digitization processes.

FUTURE RESEARCH DIRECTIONS

Based on the results obtained, future studies are encouraged to increase the sample size and include athletes of different competitive levels, age groups, and sports modalities in order to strengthen the external validity of the findings. It would also be relevant to apply the biomechanical approach to other physical tests and technical skills, both individual and team-based, to assess its impact on overall sports performance. Likewise, the inclusion of physiological and neuromuscular variables is recommended to complement biomechanical analysis. Extending the duration of the intervention would allow for the evaluation of the sustainability of performance improvements. Finally, future research could explore the integration of emerging technologies, such as inertial sensors or artificial intelligence, in sports training and assessment processes.

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AUTHORS’ CONTRIBUTIONS

Amer Mohad: contributed to the conception of the study, methodological design, implementation of the biomechanical training program, data analysis, and manuscript writing.

Mohamed Maamri: contributed to data collection, biomechanical data processing and analysis using specialized software, interpretation of results, and critical revision of the manuscript. Both authors approved the final version of the article and take responsibility for the published content.

REFERENCES

Aboul-Ezz, E. (2023). Digital media ethics between practice and application: Meta-analysis study. *The Arab Journal of Media and Communication Research (AJMCR)*, *2023*(43), 107-170.

Adel Abdul Basir Ali (1990). "Biomechanics Between Theory and Application in Sports," Port Said

Bardshaw, E. J. (2004). le-Rossignal: "Anthropometric and Biomechanical Field Measures of Floor and Vault Ability in 8 to 14-Year-Old Talent-Selected Gymnasts," New Zealand Academy of Sport, Queensland University of Technology, 2004.

Foreign References:

Lake, M. J. (2000). Determining the protective function of sports footwear. *Ergonomics*, *43*(10), 1610-1621.

Mohamed Hassan Alawi (1992). "Sports Training Science," 12th ed., Dar Al-Ma'arif, 1992.

Parslew, B., Sivalingam, G., & Crowther, W. (2018). A dynamics and stability framework for avian jumping take-off. *Royal Society open science*, *5*(10), 181544.

Qasim Hassan Hussein, Ayman Shakir (1998). "Principles of the Mechanical Foundations of Sports Movements," Dar Al-Fikr Publishing and Distribution.

Qasim Hassan Hussein, Ayman Shakir (1998). "Research Methods in Kinetic Analysis," 1st ed., Amman: Dar Al-Fikr Publishing and Distribution

Rodin, M., & Rodin, B. (1972). Student Evaluations of Teachers: Students rate most highly instructors from whom they learn least. *Science*, *177*(4055), 1164-1166.

Sayyid Abdel-Maqsoud Mohamed (1999). "Training Theories in the Basic Aspects of the Training Process," Cairo.

Susan J. Hall (1999). "Basic Biomechanics," 3rd ed., McGraw-Hill Companies, Mosby Book, Printed and Bound – Nidia.

Talha Hussein Hossam El-Din (1993). "Biomechanics (Theoretical and Practical Foundations)," Dar Al-Fikr Al-Arabi, Cairo.

Wajih Mahjoub (1987). "The Physical and Physiological Kinetic Analysis of Sports Movements," Baghdad: Higher Education Press, 2nd ed.

Yasser Atef Gharaba, Amr Abdel-Razek (2004). "Training Program Based on Some Biomechanical Indicators Affecting the Rotation Speed of the Backward Somersault Skill Followed by Two Spins Around the Longitudinal Axis," Published Research in the 1st Scientific Conference, Faculty of Physical Education for Boys, Zagazig University.