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# Effect of a training program on biomechanical indicators of basketball shooting technique

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## ABSTRACT

**Objective:** To analyze the effect of a training program on biomechanical indicators of basketball shooting technique.

**Methods:** The design was experimental and the sample consisted of 5 players from the Al-Kahraba club youth team in basketball. An appropriate training program was developed for biomechanical indicators for the stages of the scoring technique (the three steps). The intensity of the load and rest periods were taken into account according to the type of performance and the type of training.

**Results:** The momentum phase of the first step showed statistically significant improvements ($p < 0.05$), as did the strength phase ($p < 0.05$), while the power phase showed no significant change ($p > 0.05$). The momentum phase of the second step in basketball scoring improved significantly ($p = 0.046$), indicating the effectiveness of the training interventions.

**Conclusions:** The study highlights that the steps of scoring showed a great improvement through the application of biomechanical indicators. The training interventions were effective in improving performance in both the momentum and strength phases.

**KEYWORDS:** Biomechanical Indicators; Force Curve; Basketball Scoring

## 1. INTRODUCTION

The ability of the individual to continue to exert effort depends on the ability of the muscle groups to continue contracting and the passage of oxygen to the cells of the muscle groups, in addition to many physiological changes that occur in the body. Biomechanics contributes to improving training by determining the physical and skill requirements needed to perform a particular sport in a certain manner and also improves technical training through qualitative biomechanical analysis[1].

The scoring technique depends on physical and motor capabilities, which influence certain mechanical aspects of performance, such as step speed and adjusting step technique during the preparatory stage before jumping and the period of ground contact. Improving the performance of scoring steps involves not changing the method but enhancing the ability to generate force, which contributes to increasing muscular strength during performance. The researcher believes there is a strong, undeniable correlation between the stages of performing the scoring skill technique, its timing, and the mechanical variables that affect the motor path of the performance.

The rate of increasing strength from the beginning of shooting to reaching maximum force (the stage of maximum strength) involves rapid repetition of actions and neurological and physiological reactions. The stage of decreasing strength and the speed of endurance is also part of the scoring technique, aimed at enhancing the player's ability to score by developing jumping power to reach the scoring ring in the shortest time. This is crucial, as basketball is a game of seconds, with points scored in brief moments during the match[1].

Through the rapid advancements in basketball training, which have kept pace with scientific progress to enhance the training of scoring techniques, and the tremendous technological developments in measurement and evaluation tools, including biomechanical analysis, the researcher was motivated to study this progress. The study focuses on addressing the gap between international and local levels during the stages of training and identifying the most appropriate methods to improve the performance of the scoring technique by developing force load during its stages.

The problem of this research lies in its serious attempt to develop a specialized training program aimed at enhancing players' abilities (the strength curve) by achieving the most appropriate strength levels consistent with the scoring technique. The researcher observed, through follow-up of the basketball league, a weakness in strength training related to the scoring skill during the attack process. Most attacks involving this type of scoring are interrupted due to inadequate strength training. This research seeks to address this issue by developing biomechanical indicators for the scoring skill in basketball.

The research aims to develop the biomechanical indicators of the technical stages of the scoring skill in basketball by identifying the key biomechanical indicators for these stages and assessing the impact of a proposed training program on improving these indicators to enhance scoring performance.

## 2. METHODS

### 2.1. Study design and participants

The researcher employed the experimental method with pre- and post-measurements on one experimental group, utilizing biomechanical analysis based on video recording and kinetic analysis using the Kenova program

The researcher identified the research community, which was deliberately selected and consisted of 10 youth basketball players from the Al-Kahraba Club. Three players were excluded because they are left-handed, which did not align with the nature of the test, and two players were excluded due to non-participation in the post-test. As a result, the final sample comprised five players. The researcher ensured that the chosen sample accurately represented the original population under study.

### 2.2. Procedures and instruments

The devices and tools used in this research were:

- A medical scale to measure weight in kilograms.
- An altimeter to measure total height with precision.
- A digital stopwatch and start cones.
- A cyber treadmill.
- Rubber ropes, tires, sticks, and weights of various sizes.
- One Dell computer and the Kenova motion analysis program.
- Calibration boxes (1 meter x 1 meter) for calibration.
- Six Sony cameras with a speed of 100 frames per second.
- Six tripods and one data projector.

The exploratory experiment was conducted on the research sample on Thursday, June 8, 2017, as a prelude to filming the scoring skill. The scoring step distance in basketball was divided into six equal segments. Three vertical cameras were positioned to capture the player's movement from the right side at a distance of 5 meters and a height of 1 meter, and three cameras were placed on the left side at the same height and distance. The results of the reconnaissance experiment led to the following:

1. Preparation of the shooting location
2. Setup of the cameras
3. Preparation of the players for shooting

4. Determination of the stages of the basketball scoring skill technique
5. Validation of the tools and devices used for pre-measurement

The researcher then conducted the pre-measurement, where each player individually performed five attempts to score, allowing for complete rest between attempts, on Thursday, July 26, 2017.

### 2.3. Training Program

The content of the training program was determined through the results of the mechanical analysis of the technical stages of the skill of scoring in basketball according to the reconnaissance experiment and the identification of the most important biomechanical indicators. The training program was applied for a period of (8) training weeks at the rate of (4) training units per week.

Objective of the training program: Technical stages of scoring skill (first step) - (second step) - (elevation) - (jumping) and the most important biomechanical indicators (momentum) (starting stage and performing strongly (50%) - (strength) stage during the steps of scoring with basketball strongly (80 %) - the final strength stage (jumping) strongly (100%) in the skill of scoring in basketball among the research sample.

***Foundations and criteria for developing the training program[2]:***

By looking at scientific references and personal interviews with experts and trainers, the researcher determined the foundations for developing the program as follows:

- Taking into account the principles of sports training and diversity in methods to develop all stages of the shooting skill technique.
- The strength of the performance stages of the skill of scoring in basketball is gradually increasing from one week to the next
- There must be a complex and balanced psychological preparation and the development of the various physical capabilities of the player, the aim of which is the compatibility of all components of the preparation of these players.
- Taking into account the tools and devices used and the integration between the parts of the program.

The proposed training program was developed with a total of 32 training units over a period of 8 weeks, with 4 training units per week, based on expert opinions. Each training unit was divided into special physical exercises, skill exercises, and a closing segment. The total duration of each training

unit ranged from 120 to 140 minutes, depending on the intensity and the inclusion of positive rest intervals.

***Components of the training load for the training program***

- The severity of the load: The intensity of the load in the program ranged from 40: 100% of the individual's maximum performance.
- The size of the load: the time of performing the training unit ranged from (120-140) minutes, and the number of repetitions ranged between (2:5) repetitions for one exercise, and the number of groups was (1:3) groups.
- Intermediate rest periods: The researcher took into account that the intervals of interstitial rest are sufficient so as not to overload, which leads to the occurrence of the injury intended for the research sample.

After completing the application of all the training units, the researcher conducted the post-measurement on the research sample under the same conditions as the pre-measurement. Each player individually performed five attempts at the scoring skill, with complete rest between attempts, on Sunday, July 9, 2017, in the indoor hall of the Electricity Basketball Club.

### 2.4. Statistical analyses

The researcher used the Statistical Package for the Social Sciences (SPSS), version 25. The statistical techniques applied included the arithmetic mean, standard deviation, Wilcoxon test, and percentages. The significance level was set at $p < 0.05$.

## 3. RESULTS

Table 1 shows the average attempts of five players across different stages of the scoring skill in basketball. It highlights improvements in all phases (momentum, strength, and power) demonstrating the players' enhanced performance, particularly in the high jump phase. The data reflects steady progress in each player's ability to execute the skill, with notable increases in the power phase for all players.

**Table 1.** Average attempts of players in biomechanical stages of the basketball scoring skill

| Attempts | Stages of scoring skill technique | The first step | | The second step | | To ascend (jump) | |
|---|---|---|---|---|---|---|---|
| | | Before | After | Before | After | Before | After |
| Average attempts of the first player | Momentum (start-up phase and strong performance, 50%) | 2.20 | 2.33 | 4.33 | 4.69 | 8.05 | 9.80 |
| | Strength phase during the basketball scoring steps (80%) | 2.72 | 2.79 | 5.79 | 6.03 | 10.57 | 11.19 |
| | Power phase (final) – high jump (100%) | 6.77 | 7.22 | 10.11 | 11.13 | 12.33 | 13.45 |
| The average of the second player's attempts | Momentum (start-up phase and strong performance, 50%) | 2.29 | 2.66 | 5.01 | 6.12 | 8.38 | 10.11 |
| | Strength phase during the basketball scoring steps (80%) | 3.99 | 4.05 | 6.45 | 7.77 | 10.23 | 12.31 |
| | Power phase (final) – high jump (100%) | 7.11 | 8.41 | 10.88 | 12.29 | 13.44 | 14.12 |
| The average of the third player's attempts | Momentum (start-up phase and strong performance, 50%) | 2.24 | 2.55 | 4.44 | 5.22 | 9.36 | 10.12 |
| | Strength phase during the basketball scoring steps (80%) | 3.55 | 4.11 | 5.63 | 6.79 | 10.12 | 11.69 |
| | Power phase (final) – high jump (100%) | 6.13 | 7.89 | 10.19 | 11.98 | 12.77 | 13.87 |
| The average of the fourth player's attempts | Momentum (start-up phase and strong performance, 50%) | 2.88 | 3.76 | .456 | 5.89 | 8.69 | 9.97 |
| | Strength phase during the basketball scoring steps (80%) | 3.44 | 4.61 | 6.02 | 7.93 | 11.22 | 12.67 |
| | Power phase (final) – high jump (100%) | 5.88 | 7.69 | 11.19 | 12.33 | 13.29 | 14.88 |
| Average attempts of the fifth player | Momentum (start-up phase and strong performance, 50%) | 3.01 | 3.98 | 4.77 | 5.67 | 8.57 | 9.78 |
| | Strength phase during the basketball scoring steps (80%) | 4.39 | 5.67 | 6.67 | 7.76 | 10.22 | 12.29 |
| | Power phase (final) – high jump (100%) | 6.89 | 7.97 | 10.28 | 11.83 | 12.68 | 13.89 |

Table 2 shows the significance of the differences between the pre- and post-measurements in the biomechanical indicators of the first step of the basketball scoring skill. The table indicates that the momentum phase (start-up phase and performance strongly) and the strength phase showed statistically significant improvements ($p < 0.05$), with change rates of 1.79% and 3.45%, respectively. However, the power phase did not show a statistically significant change ($p > 0.05$).

**Table 2.** Differences in biomechanical indicators of the first step of basketball scoring between pre- and post-measurements

| **Biomechanical indicators** | **The unit of measure-ment** | **Pre-test mean** | **Post-test mean** | **Rank average** | | **z** | ***p*** | **Change rate (%)** |
|---|---|---|---|---|---|---|---|---|
| | | | | **-** | **+** | | | |
| Momentum (start-up phase and strong performance, 50%) | kg/m/sec2 | 3.22 | 4.23 | 5.67 | 2.51 | 2.67 | 0.022 | 1.79 |
| Strength phase during the basketball scoring steps (80%) | Newton | 9.87 | 10.12 | 3.76 | 3.23 | 3.22 | 0.036 | 3.45 |
| Power phase (final) – high jump (100%) | Newton | 10.86 | 11.89 | 0.78 | 4.12 | 4.68 | 0.119 | 5.12 |

*Statistically significant at $p < 0.05$.*

Table 3 shows the significance of the differences between the pre- and post-measurements in the biomechanical indicators of the second step of the basketball scoring skill. The table reveals that the momentum phase (start-up phase and performance strongly) showed a statistically significant improvement ($p = 0.046$), with a change rate of 1.88%. The strength phase and power phase did not show statistically significant changes ($p = 0.065$ and $p = 0.122$, respectively).

**Table 3.** Significance of the differences between pre- and post-measurements in the biomechanical indicators of the second step of basketball scoring skill

| **Biomechanical indicators** | **The unit of measure-ment** | **Pre-test mean** | **Post-test mean** | **Rank average** | | **z** | ***p*** | **Change rate (%)** |
|---|---|---|---|---|---|---|---|---|
| | | | | **-** | **+** | | | |
| Momentum (start-up phase and strong performance, 50%) | kg/m/sec2 | 3.78 | 4.89 | 5.78 | 5.96 | 2.78 | 0.046 | 1.88 |
| Strength phase during the basketball scoring steps (80%) | Newton | 9.78 | 10.87 | 3.65 | 3.79 | 4.45 | 0.065 | 3.76 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Power phase (final) – high jump (100%) | Newton | 11.67 | 12.44 | 4.56 | 4.87 | 5.54 | 0.122 | 5.77 |

*Statistically significant at p < 0.05.*

Table 4 shows the significance of the differences between the pre- and post-measurements in the biomechanical indicators of the third step of the basketball scoring skill. The momentum phase showed a change rate of 2.12%, with a p-value of 0.057, which is close to the threshold for statistical significance. The strength phase had a change rate of 4.12% with a p-value of 0.079, and the power phase showed a change rate of 6.57% with a p-value of 0.178. All p-values are above the threshold of 0.05, suggesting that the changes are not statistically significant at the 5% level.

**Table 4.** The significance of the differences between the pre and post measurement in the biomechanical indicators of the third step of basketball scoring skill

| **Biomechanical indicators** | **The unit of measure-ment** | **Pre-test mean** | **Post-test mean** | **Rank average** | | **z** | ***p*** | **Change rate (%)** |
|---|---|---|---|---|---|---|---|---|
| | | | | **-** | + | | | |
| Momentum (start-up phase and strong performance, 50%) | kg/m/sec2 | 4.54 | 5.34 | 6.45 | 7.13 | 3.46 | 0.057 | 2.12 |
| Strength phase during the basketball scoring steps (80%) | Newton | 10.87 | 11.67 | 4.37 | 5.78 | 5.44 | 0.079 | 4.12 |
| Power phase (final) – high jump (100%) | Newton | 12.38 | 13.45 | 5.65 | 6.39 | 6.79 | 0.178 | 6.57 |

*Statistically significant at p < 0.05*

## 4. DISCUSSION

The study showed that regarding the first step, the momentum phase (start-up phase and performance strongly) and the strength phase demonstrated statistically significant improvements ($p < 0.05$), while the power phase did not show a statistically significant change ($p > 0.05$). The researcher attributes these changes to an interest in the scoring technique in basketball, particularly the forward inclination of the torso during the starting phase.

The frequency of force increases due to changes in the movement of the legs during the transition from the first to the second step. As the speed increases, the rate of strength also rises, preparing the body for the jump in the third step. At this stage, the body achieves maximum momentum to ascend toward the scoring ring, with added deception during the ascent, allowing the player to score effectively with either arm [3-5].

Our study indicated that the momentum phase of the second step in the basketball scoring skill improved significantly ($p = 0.046$), suggesting that training interventions effectively enhanced this aspect. However, the lack of statistically significant changes in the strength ($p = 0.065$) and power phases ($p = 0.122$) may point to limitations in the training's impact on these phases or the need for more targeted interventions to achieve measurable improvements. This highlights the importance of focusing on specific biomechanical aspects to optimize overall performance. According to Simonian[7], players increase their strength and speed to the maximum possible degree by moving between the steps and the gradual increase in order to reach the maximum power before rising and maintaining the strength gained from the two steps.

Furthermore, the current study showed the significance of the differences between the pre- and post-measurements in the biomechanical indicators of the third step of the basketball scoring skill. The momentum phase showed a change rate of 2.12%, with a p-value of 0.057, which is close to the threshold for statistical significance. The strength phase had a change rate of 4.12% with a p-value of 0.079, and the power phase showed a change rate of 6.57% with a p-value of 0.178 (no statistically significant).

Through the transfer of strength and energy from one step to another, up to the stage of upgrading the greatest strength and energy gained from the steps of scoring, this results in improvement of technique and accuracy in scoring. It is necessary to select the appropriate training and exercises, because the higher the level of performance of the players, the less range of available exercises that develop skillful performance, and then the course of the training program changes from being just a general preparation to a more specialized preparation that qualifies the player to develop skillful performance[8].

The majority of trainers focus on improving strength and speed through resistance training, as strength training with resistance enhances leg muscle strength by increasing resistance. This can be achieved through methods such as using body weight, weights, parachutes, and inclined surfaces. These approaches serve as factors that increase resistance, thereby improving strength, which in turn leads to an increase in speed[6].

The skill of scoring is influenced by various training and biomechanical factors. In this research, the researcher aims to incorporate a biomechanical training principle to enhance the gradient of force (the force curve) by minimizing lateral forces and reducing the player's weight through the applied

training program. This principle is considered one of the key factors contributing to the improvement of strength levels[7].

The results of this study align with the findings of Hay[9], which emphasize that as player progress in strength and speed development programs, it becomes crucial to select appropriate training and exercises. This is because, at higher performance levels, the range of exercises that effectively enhance skillful performance narrows. Consequently, the focus of the training program shifts from general preparation to more specialized preparation, enabling players to improve their strength specifically for the basketball scoring skill[9].

## 5. CONCLUSIONS

The study highlights that the steps of scoring showed the greatest improvement through the application of biomechanical indicators. Developing the strength level, reflected in the force curve, relies on the player's ability to sustain strength throughout the stages of the scoring skill technique. Biomechanical indicators proved to be the most influential during the scoring steps, particularly in the various stages of the technique. Following the implementation of the training program, improvements were observed in momentum and the curved strength level during the scoring steps, with emphasis on maintaining strength during the ascent phase leading to the final scoring.

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**AUTHOR CONTRIBUTIONS**

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

**CONFLICTS OF INTEREST**

The authors declare no conflict of interest.

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