

Multi-Axial Strength Training on Some Bio-Motor Abilities in Basketball for Ages (14-16)

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Abstract. The significance of the research emerged through the use of a training method focusing on multi-axial strength to develop bio-motor abilities, which serve some basketball skills by achieving a point with minimal effort and maximum efficiency, as observed in global leagues. The research aimed to prepare specific exercises for multi-axial neuromuscular activation to develop bio-motor abilities and to identify the effect of these specific multi-axial strength exercises on bio-motor abilities. The researcher hypothesized that there are statistically significant differences between the pre- and post-tests for the research group in some bio-motor abilities in basketball. The researcher used the experimental approach due to its suitability to the nature of the research problem, adopting an equivalent-group design with pre- and post-tests, as this design provides strict control and suits the research procedures. The research sample consisted of (16) youth players from Al-Numaniya Sports Club. The researcher and the assisting team conducted the tests over a single day at the youth center hall of Al-Numaniya Sports Club. The main experiment involved applying strength exercises according to multiple axes specific to the performance of basic basketball skills. Upon completing the implementation of the applied exercises prepared by the researcher, post-tests were conducted on (10/10/2024) for a duration of one day. The researcher utilized the Statistical Package for the Social Sciences (SPSS) to obtain the research results.

Keywords: Basketball; Biomotor Abilities; Experimental Design; Multiaxial Strength; SPSS Analysis.

1. INTRODUCTION

Activating the neuromuscular system according to the required motor duty is the vital focal point upon which the development of physical abilities rests within the framework of achieving high performance. All of this depends on the integration of sciences that strive to find the best and most effective solutions to serve the game of basketball in general and its skills in particular.

Bio-motor abilities (such as explosive power, ranges of motion, and dynamic balance) for body parts during the execution of a motor duty are the foundation upon which basic skills are built due to the specificity of the performance. This requires significant attention when designing training curricula for these skills, as well as the use of training means, methods, or styles directed toward serving the duty according to the performance levels of the skill. Among these methods is the use of strength training tailored to the multiplicity of the motor duty for the axes and levels of skills, which must be considered, keeping in mind that every open skill requires the player to change the position of their body parts during performance.

Hence, the importance of this research arises from using a training method that works on neuromuscular activation through multi-axial strength exercises to develop bio-motor abilities, ultimately serving the skills to score points with the least effort and highest efficiency, as witnessed in global leagues.

Research Problem

By following the first division league, the researcher noticed that the performance of basic skills is characterized by the player's inability to change direction, jump, correct body posture, and loss of balance under opponent pressure. If the player attempts to rapidly change directions with the ball, they lose the ability to effectively direct it. This is largely due to the nature of the training, which is predominantly monotonous and fails to simulate the working muscles according to the specific multiple axes of the skill. Most coaches utilize training of a known, stereotypical nature (flexion and extension). The lack of attention to altering training axes negatively reflects on the development of abilities required to serve the motor duty. Therefore, the researcher attempts to delve into an experiment that would bridge this vast gap by employing specific multi-axial exercises to achieve physical ability development in a direction that serves the motor duty and elevates the overall reality of this game.

Research Objectives:

- a. Preparing specific multi-axial strength exercises to develop bio-motor abilities.
- b. Identifying the effect of specific multi-axial strength training on bio-motor abilities.

Research Hypotheses

- a. There are significant differences between the pre- and post-tests for both the control and experimental groups in certain bio-motor abilities.

Research Domains

- a. Human Domain: Youth players of Al-Numaniya Club.
- b. Time Domain: 20/7/2024 - 10/10/2024.
- c. Spatial Domain: Al-Numaniya Club Youth Center.

2. RESEARCH METHODOLOGY

Research Methodology

Since the research problem is experimental in nature, the researcher used the experimental approach due to its suitability. An equivalent-group design with pre- and post-tests was employed, as this design ensures tight control and is appropriate for the research procedures (Ali et al., 2022; Mohammed et al., 2025).

Research Population and Sample

The research sample consisted of youth players from Al-Numaniya Sports Club, numbering (10) players, representing the group under study.

Homogeneity of the Research Sample

Table 1. Shows the Arithmetic Means, Standard Deviations, Medians, and Skewness Coefficients for the Investigated Variables (Height, Weight, Chronological Age, Training Age, Arm Length, and Leg Length) of the Research Sample, as Illustrated in the Table.

Variables	Unit of Measurement	Arithmetic Mean	Median	Standard Deviation	Coefficient of Variation	Skewness Coefficient	Levene
Height	m	1.809	1.805	0.042	2.321	0.290	0.328
Mass	kg	68.766	68.850	5.102	7.419	0.415	0.144
Chronological Age	Year	17.583	17	0.996	5.664	0.388	0.461
Training Age	Year	5	5	1.206	24.12	0.373	0.334

As evident from the table above, the skewness coefficient was less than (± 1), confirming the homogeneity of the research sample in the aforementioned variables.

Means, Tools, and Devices Used in the Research: 2.3.1 Data Collection Means:

- Observation.
- Measurements and tests.
- Personal interviews.
- The Internet.

Tools Used in the Research

- Whistles (2).
- Medicine balls of various weights (8).
- Swedish benches (8).
- Jumping hurdles of various heights (14).
- Various weights/dumbbells (12).
- Balance balls (4).
- Measuring tape.
- Mats (2).

Devices Used in the Research

- Electronic stopwatches (2).
- Medical scale for measuring weight.
- Video camera (240) frames/sec.
- Video camera (120) frames/sec.
- Laptop computer.

Tests Used

- Instantaneous leg power test (Modified) (Hassan, 2018, p. 88).

Test Name: Instantaneous leg power test.

- Power test for the striking arm (Modified) (Al-Hakim, 1994, p. 14).

Test Name: Instantaneous power test for the striking arm.

- c. *Second Test:* Strength characterized by speed test for the leg muscles.

Test Name: Three-step jump run test (Kadhim, 2016, p. 99).

- d. *Motor Balance Test:* Y-BALANCE TEST (Trojian & McKeag, 2006, p. 40).

Test Purpose: Dynamic balance of the lower and upper limb muscles.

Exploratory Experiment

The researcher conducted the first exploratory experiment concerning the used exercises on Friday (12/10) at 4:00 PM on the players of the experimental group. Its aims were:

- a. Determining the suitability of the designed exercises for the research sample's level.
- b. Determining the maximum intensities for each exercise and for each practitioner individually.
- c. Determining the time required for the specific training of the experimental group.

Pre-tests

The researcher and the assisting team conducted the (bio-motor) tests over a single day at the youth center hall of Al-Numaniya Sports Club. After providing the necessary instructions on how to perform the tests and their sequence, the tests commenced. On the first day, Saturday, 23/10/2024, the researcher conducted the tests for bio-motor variables at exactly 3:00 PM. The researcher ensured the availability of required devices, tools, the assisting team, and the team's coach to complete the tests while providing all suitable conditions for their success.

Training Used

The main experiment included applying multi-axial neuromuscular activation exercises targeting the lower limbs, central axis, and arms. The exercises were within the stretch-shortening cycle using an unbalanced method. Exercises were performed according to the working axes while applying strength training with varying loads on different body parts or the whole body, achieved by increasing or decreasing the actual weight of the body or a specific part. Additionally, a training method combining static hold-relaxation with the contraction of agonist muscles (neuromuscular stretching across multiple axes) was utilized. The researcher designed the exercises to align with solving the problem identified in the study to elevate skill levels. The exercises simulated the nature of the skills based on their working axes, ensuring suitability for the sample's level to prevent injuries given the approaching league. The primary goal was to enhance bio-motor abilities suitable for the performance nature of most skills using the interval training method for both unbalanced exercises and hold-relax contraction exercises.

The training was implemented during the specific preparation period, lasting (10) weeks at a rate of (3) training units per week (Saturdays, Mondays, Thursdays), totaling thirty training units.

The unbalanced strength training within the neuromuscular stretch-shortening cycle across multiple axes employed the hold-relax method with agonist muscle contraction. This technique involves an eccentric stretch with the specific part fixed at maximum extension, followed by a concentric contraction of the antagonist muscles. It is executed by having a coach or colleague hold the limb at its maximum reachable range via an eccentric contraction for a limited duration of (10) seconds, followed by a brief muscle relaxation period of (5) seconds. Once the player feels capable of a concentric contraction, the coach or colleague resists this movement so the contraction transitions from isometric to a shortening contraction for (10) seconds. The player is given adequate rest before repeating the exercise.

Post-tests

After the applied exercises were completed, post-tests were conducted on (10/10/2024) [sic] for a single day using the exact same procedures as the pre-tests, maintaining the same location, timing, conditions, test sequence, assisting team, equipment, and tools as closely as possible.

Statistical Methods

The researcher utilized the Statistical Package for the Social Sciences (SPSS) to obtain the results (Abdullateef AbdulJabbar et al., 2025; Fayyad et al., 2025, 2026; Khalaf et al., 2025).

3. RESULTS

Presentation, analysis, and discussion of the pre- and post-tests results in certain bio-motor abilities for the research group.

Table 2. Shows the Arithmetic Means, Standard Deviations, t-Values, Mean Differences, and Significance Levels for the Strength-Related Variables between the Pre- and Post-Tests for the Experimental Research Group.

Group	Variables	Unit of Measurement	Pre (Mean $\pm$ SD)	Post (Mean $\pm$ SD)	Mean Diff	SD Diff	t-value	Sig. Level	Significance
Experimental	1 Explosive Leg Power	Watt	2035 $\pm$ 63.85	2587 $\pm$ 61.86	552	172.9	7.820	0.001	Significant

2	Strength Characterized by Speed (Legs)	Newton	1384 ± 95.21	1717.83 ± 75.92	333.86	144.99	5.64	0.002	Significant
3	Explosive Arm Power	Watt	1101.33 ± 70.27	1578 ± 61.77	476.66	150.28	7.769	0.001	Significant
4	Dynamic Balance (Y Balance) - Right Leg	cm	52.66 ± 5.04	68.83 ± 3.31	16.16	5.32	7.570	0.001	Significant
	Dynamic Balance (Y Balance) - Left Leg	cm	49.5 ± 4.41	64.16 ± 5.49	14.66	7.68	4.675	0.005	Significant
5	Dynamic Balance (Y Balance) - Right Arm	cm	40.16 ± 4.87	58 ± 4.97	17.83	5.38	8.116	0.000	Significant
	Dynamic Balance (Y Balance) - Left Arm	cm	33.83 ± 2.48	53.16 ± 3.98	19.33	7.28	7.510	0.001	Significant

(Note: Variables numbering adjusted for clarity based on source tables)

- (*) Degree of freedom (12).
- (*) Significant at the significance level (0.05) if the error level is $\leq$ or $=$ (0.05).

4. DISCUSSION

Discussion of the Pre- and Post-test Results for the Experimental Group in the Study Variables.

The researcher presented and analyzed the results of the pre- and post-tests for the experimental group in Table (3) [sic]. It is evident that there are statistically significant differences between the pre- and post-tests across the study variables. The researcher attributes this to the specific nature of the training given to the basketball players, which aimed to develop physical abilities by activating muscles along the skill axes. The exercises simulated the nature of the skills using a standardized scientific approach; the researcher used stretch-shortening cycle exercises via an unbalanced strength method, manipulated through relative weights on body parts and partial changes to the flat surface the players trained on. These exercises, designed by the researcher, relied on scientific foundations and were formed to suit the sample's nature and level. They targeted the highly specific muscles involved in the performance. Integrating elements to develop both speed and strength simultaneously improved the

performance of this activity, agreeing with Ali and Sajit (2017, p. 23) that "training means or specific exercises executed to achieve an effective training impact must be drawn from the sport itself and engage the muscles that dominate the speed, strength, and movement direction of the skill".

Furthermore, Omosegaard (1999, p. 92) emphasizes that specific stretch-shortening cycle exercises are highly effective for developing abilities (explosive power and fast strength), as they impose physical stress on the body—especially on the working muscles and tendons—enhancing specific muscular strength aligned with the specialized activity. This reflected positively on the "explosive power of the arms, legs, trunk, and balance," yielding positive improvements in the post-test results.

The researcher also attributes the development of the study variables to the scientific shift in training patterns. Simulating strength training along working axes (horizontal, longitudinal, and deep) is a novel approach to developing all engaged muscles while respecting the proportions of their muscular engagement. Because most training follows a traditional uni-axial pattern, the researcher purposely incorporated multiple axes into single exercises, replicating competitive scenarios. Al-Fadhli (2020, p. 77) confirms the critical nature of multi-axial strength training in linear movements, as well as the even greater importance of rotational strength training. Multi-axial rotational strength training is the foundation of human strength conditioning, reflecting the body's biomechanics of levers and joints associated with multi-axial movements; practically all body movements are rotational, turning around joint axes with body mass distributed around them.

The researcher asserts that stretch-shortening cycle training using calibrated relative weights—shifting weights between parts to deliberately unbalance the execution—forces the player to fight to maintain body position and form. This intensely stimulates working muscles to overcome resistance and maintain muscular balance by elevating neural stimulation via sensory receptors. These receptors provide actionable feedback regarding bodily shifts. As Hung (2015, p. 434) noted, proprioceptive auto-stimulation allows the body to alter muscle contraction in direct response to external forces, granting it the ability to sense orientation within its environment despite external disruptions (e.g., knowing your arm is raised even with closed eyes). Stretch receptors in the muscles track joint positions. These systems work in concert to establish muscular balance and preserve mobility and function. Continuously strengthening these systems prevents injuries and the risk of falling during skill execution. This "sense of strength" (also known as the sense of effort, heaviness, or tension) is the ability to repeatedly reproduce a required force level matching the motor duty. It originates from afferent

feedback embedded within the Pacinian corpuscles, Meissner's corpuscles, Ruffini endings, Merkel discs, Golgi tendon organs, and muscle spindles within our muscles, joints, and skin.

5. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Based on the presentation, analysis, and discussion of the results, the following was concluded: Multi-axial strength training has a positive impact on developing the specific physical abilities of the working muscles targeted in this research. Multi-axial strength training is critically necessary for inducing changes in muscle strength across the various axes of the parts responsible for performance (lower limb, central axis, and upper limb). The exercises successfully simulated the motor and mechanical nature of performance sequencing across different working axes, prompting qualitative shifts that elevated the players' performance levels. The training had a remarkable effect on increasing strength, as evidenced by the relative strength indicators and the clear difference in power between the pre- and post-tests.

Recommendations

In light of the conclusions, the researcher recommends the following: Utilizing multi-axial strength training due to its significant impact on developing various forms of strength. Utilizing multi-axial strength training to develop specific, fine working muscles that are often neglected due to the technique of most traditional training regimens. Prioritizing multi-axial strength training and making it a fundamental pillar in developing basketball skills. Conducting further studies and research using multi-axial neuromuscular activation training on other demographics, such as advanced and junior players.

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