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Effect Of Four Weeks Complex Training On Muscular Strength And Functional Performance In Basketball Players

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Abstract

Introduction: Basketball is a high-power sport; it requires adequate amalgamation of skills and strength. The current study aims to figure out the effect of four weeks of complex training on strength and other parameters like functional performance in basketball players.
Methods: Forty-eight male basketball players (mean age years: 20.19±1.684; height: 1.7787±.04836; BMI: 22.72 ±1.02) were blindly randomized into an experimental group (EG; complex training) and a control group. At baseline overall no differences were there between the groups. Both groups participated in their respective training sessions twice per week for 45 minutes each day for four weeks, and, using a pre-test/post-test experimental design, upper limb strength, lower limb strength, vertical jump, and shooting accuracy were assessed.
Results: From pre- to post-intervention across all measured variables, improvement was noted in Experimental (EG) and Control Group (CG). At the same time, comparative analysis indicated that the EG significantly outperformed the CG, as the former group showed superior improvements in upper limb strength ($t = -3.61$, $p = 0.002$, $d = 1.2$), lower limb strength ($t = -4.12$, $p < 0.001$, $d = 1.4$), vertical jump performance ($t = -3.92$, $p < 0.001$, $d = 1.3$), and shooting accuracy—both from 2-point (S2P60: $t = -3.15$, $p = 0.003$, $d = 1.1$) and 3-point ranges (S3P60: $t = -2.98$, $p = 0.005$, $d = 1.36$).
Conclusion: Complex training markedly improves strength and functional performance in basketball players compared to regular training, improving key skills like jumping and shooting.

Keywords: Jumping Performance, Shooting Performance, Limb strength, Post-activation potentiation.

1.INTRODUCTION

Basketball being a dynamic sport, is played between two teams containing five players each. Players gain points by targeting the hoop heightened at 10 foot in the opponent's area for shooting. In basketball, field goals from in front of the three-point line are for two points, while those from beyond it is worth three. Position of the player in game is decided by physical trait they have and skill sets they've developed through practice.(Altavilla et al., 2020)
This game demonstrates dynamism via a variety of activities including both high-intensity motions, such as jumping, turning, dribbling, and running, as well as low-intensity actions, such as walking and pausing. The capacity to often transition between offensive and defensive positions requires a notable degree of smooth transition of multi-segmental motion for greater shooting accuracy, vertical jumping capability and swift changes in direction. In the context of a 40-minute game, it has been shown that professional players possess the ability to cover distances varying between 3500 and 5000 meters. The enhancement of physical strength and endurance in the upper and lower body both, along with speed, and agility, is vital for players to excel in game. Above-mentioned physiological characteristics have a role in the initiation of both aerobic and anaerobic metabolic processes, hence promoting the production of energy throughout the duration of the game.(Stojanović et al., 2018)

The development of body strength is crucial for basketball players as it plays a vital role in enhancing power and endurance during on-court activities. Offensive and defensive circumstances in basketball entail the engagement of several components of the anterior, posterior, and lateral shoulder complex.(Wen et al., n.d.) A evaluation of shooting effectiveness in basketball is widely acknowledged by both players and coaches as a crucial factor in attaining a successful performance. This is due to the fact that in basketball, teams earn points by successfully shooting the ball into the opponent's hoop. The increased level of strength leads to a corresponding augmentation in the angular velocity of the shoulder joint, hence enhancing shooting accuracy via an increase in the angle of release of the ball, while jump height is an additional variable.(Apaak et al., 2022) An increase in release height of the ball is observed by raising the jump height and integrating it with greater release angle, which results in better shooting accuracy, as it intends the ball to follow a parabolic path.(Okazaki et al., 2015) Ball's release height is directly impacted by player's standing height, jump height, and their ability to organize segmental motions.(Alemdaroğlu, 2012)

Complex training (CT) refers to the practice of using both conventional resistance training, which involves using heavy loads, and plyometric exercises, which include using low weights, within a single session and with limited rest intervals. Weight training and plyometric training have always been seen as mutually beneficial and complementary forms of exercise.(Ebben, 2002)

The goal of Complex training is to enhance an individual's ability to generate more power during subsequent sets with smaller loads. In a more precise manner, it has been observed that CT has the potential to enhance motor unit excitability, and hence by the physiological process increase the central input to the motor unit. Additionally, CT may facilitate the transfer of phosphate group of the myosin light chain, thereby enhancing the sensitivity of the myofilaments for the calcium. Furthermore, CT may have the effect of reducing presynaptic inhibition, which theoretically enables a subsequent augmentation of power output. The term used to describe this reaction is post-activation potentiation (PAP).(Chiu et al., 2003)

While many studies have been undertaken to analyze the result of both plyometric and strength training (complex training) on lower limb of athlete, less focus has been devoted by researchers to examining its impact on the upper body. Several studies have found mixed results regarding the efficacy of combining plyometric exercise and weight training for the upper limb.(Morris et al., 2022) However, none of the studies conducted investigations on the potential outcome of complex training on the strength required for game and functional performance, specifically in relation to shooting abilities. The present study strived to find resultant of complex training's effects on muscular strength of upper and lower limb along with the effect on functional performance like shooting ability and jumping performance in male basketball players.

2.SUBJECTS AND METHODS

2.1.Study design

A pretest-posttest experimental research methodology is implemented in the study.

2.2.Participants

Male basketball players (age: 18–25 years) with playing experience of at least 3 years were were recruited for the study and randomly divided into an experimental (EG) (complex training)(Watts et al., 2012) and is control (regular training) group (CG).(11)

Participants who were not able to perform the exercises or with history of any major musculoskeletal, cardiovascular, vestibular or neurological surgery or disorder in the previous six months that could turn out to be a cause to limit participation in the program were refrained from participating in the study. Prior information was given to the participants regarding the training protocol and associated risk factors involved in the study before receiving written and verbal consent which were in compliance with ethical standards that governs human research.

2.3.Sample size

The sample size was calculated by carrying out the analysis using G*Power (software version: - 3.1.9.2) keeping $\sigma 1, \sigma 2$=4.4, $z_1 - \frac{\alpha}{2}$ =1.96, at 95% confidence interval with 80% power and delta is 5 using. The lost to follow up being 20%.48 male basketball players between the age of 18 – 25 were recruited through purposive sampling for this study, then they were divided into control group and experimental group having 24 participants each via blinded randomization.

2.4.Outcome Measures

To evaluate the effects of the intervention, a series of performance-based outcome measures were employed.

1.Upper Limb Strength: 90-Degree Push-Up Test

To assesses strength, endurance of the upper body, particularly the muscles involved in pushing movements. While specific reliability data for a 90-degree push-up test in basketball players is not readily available, push-up tests generally are considered reliable for assessing upper body strength.(McManis et al., 2000)

2.Lower Limb Strength: Triple Hop Distance Test

To assess lower limb strength and power triple hop distance test is considered as reliable test. It involves hopping three times on one leg and measuring the total distance covered. This test has shown excellent reliability. In basketball players, such tests are crucial for evaluating lower limb function and return to sport readiness.(Farraye et al., 2023)
3.Jumping Performance: Vertical-Jump Test
The mentioned test measures explosive power.it is a common assessment tool used frequently in sports. While specific reliability data for basketball players is not detailed here, vertical jump tests are generally reliable for evaluating lower limb power.(Myers et al., 2014)
4.Shooting Accuracy: S2P60 and S3P60 Dynamic Shooting Tests
These tests assess shooting accuracy under dynamic conditions. However, specific reliability data or validation studies for these tests in basketball players are not readily available in the provided search results. Generally, shooting accuracy tests are crucial for evaluating technical skills in basketball.(Pojskic et al., 2011)

2.5.Intervention
All tests and interventions were done at the Sports Camp in Daryaganj and the Moti Lal Nehru College in New Delhi. The intervention is made up of two meetings in a week for four weeks. Each lesson lasts about 40–50 minutes. So, there were a total of eight training lessons. After warm-up, participants in the experimental and control groups underwent their respective training protocols under coach supervision, with the former engaging in complex training and the latter in regular training. Control group was asked to refrain themselves from indulging in any kind of new training protocol.

Table 1.Complex training protocol (Day 1)

Day 1			**Sets**	**Reps**	**Intensity**	**Rest**
Complex Pair 1	Heavy Resistance Exercise	Power Snatch	3	3	90% of 3 RM	2 minutes rest between exercises and between complex pair sets
	Plyometric Exercise	Medicine ball Underhand Throws	3	3	3-5kg	
Complex Pair 2	Resistance Exercise	Back Squat	3	1	90% of 1-RM	
	Plyometric Exercise	Depth Jumps	3	3	No load	
Load-Maintenance		Front Squat	3	10		2 minutes
*By Watts D, Kelly V, Young K.						

Table 2. Complex training protocol (Day 2)

Day 2			**Sets**	**Reps**	**Intensity**	**Rest**
Complex Pair 1	Heavy Resistance Exercise	Power Clean	3	3	90% of 3 RM	2 minutes rest between exercises and between complex pair sets
	Plyometric Exercise	Spike jump	3	3	Unloaded	
Complex Pair 2	Resistance Exercise	Front Squat	3	1	90% of 1-RM	
	Plyometric Exercise	Standing long Jumps*5	3	1	No load	
Load-Maintenance		Front Squat	3	10		2 minutes
*By Watts D, Kelly V, Young K.						

2.6.Statistical analysis
Data summarisation was done applied to recapitulate all the participants' demographic data and baseline measures. Statistical significance was taken as $p < 0.05$. SPSS software version 26.0 (IBM Corp., Armonk, NY, USA) was used to carry out the statistical analysis in the study.
Changes in criterion measures following intervention were equate between groups by administrating independent t-test and within the groups by paired t-test.

3.INFORMED CONSENT:
All participants signed informed consent prior to enrolment in the study, and they were free to withdraw at any time at their free will. Participants were informed that there are no risks associated with the study, and their confidentiality is ensured throughout the study.

4.ETHICAL APPROVAL:

Ethical committee of the Indian Spinal Injuries Centre Institute of Rehabilitation Sciences approved the study (Ref: ISIC/RP/2023/010). Participants were informed in detail about the training protocol and associated risk factors involved in the study before receiving written and verbal consent which were in compliance with ethical standards that governs human research.

5.RESULTS

Data was collected from forty-eight male basketball players (mean age years: 20.19±1.684; height: 1.7787±.04836; BMI: 22.72 ±1.02) were randomized into two divisions, an experimental group (EG) and control group (CG).

All the players completed 4-week training programme without any dropout and during the sessions no undesirable symptoms was observed or reported by the participants.

The analysis of subject's demographics in their respective groups is shown in the Table.

Table 3.Descriptive statistics of participants

DEMOGRAPHICS		
Parameters	**Experimental Group** (Mean ± SD)	**Control Group** (Mean ± SD)
Participants(N)	24	24
Age (YEARS)	20.8 + 1.7	19.5 + 1.4
Height (In meters)	1.7 + 0.05	1.7 + 0.05
Weight (In kg)	72.7 + 2.5	70.9 + 2.3
BMI (kg/m2)	22.8 + 0.05	22.5 + 1.07

Within the Group analysis							
Variables	**Weeks**	**Experimental**			**Control**		
		Mean ± SD	**t-value**	**p-value**	**Mean ± SD**	**t-value**	**p-value**
Push-up test	**Pre**	33.37±4.9	-17.05	<0.001*	29.57±5.8	-10.46	<0.001
	Post	37.98±4.5			32.6±5.7		
Vertical Jump Height Test	**Pre**	25.46±2.1	-9.13	<0.001	23.6±2.6	-17.76	<0.001
	Post	27.27±1.7			24.61±2.6		
Triple hop-Distance test(left)	**Pre**	636.35±21.4	-7.66	<0.001	620.66±31.3	-8.17	<0.001
	Post	654.34±24.3			631.9±27.1		
Triple hop-Distance test(right)	**Pre**	641.53±30.4	-16.9	<0.001	621.87±27.4	-11.36	<0.001
	Post	657.05±30.8			632.34±26.2		
S2P60	**Pre**	13.92±1.2	-18.31	<0.001	11.78±1.3	-20.39	<0.001
	Post	15.94±1.06			13.07±1.2		
S3P60	**Pre**	11.1±1.4	-10.82	<0.001	9.78±1.4	-14.34	<0.001
	Post	12.96±1.05			10.78±1.5		

SD: Standard Deviation; *p<0.05 (significant); S2P60: Dynamic 2 point shooting test in 1 minute; S3P60: Dynamic 3 point shooting test in one minute

Table 4. Within the group analysis of all variables in both groups

Table 5. Between the group analysis of all variables in both groups

Between the Group analysis					
Variables	**Weeks**	**Control**	**Experimental**	**t-value**	**p-value**
		Mean ± SD	**Mean ± SD**		
Push-up test	**Pre**	29.57±5.8	33.37±4.9	-2.43	<0.05
	Post	32.6±5.7	37.98±4.5	-3.61	<0.01
Vertical Jump Height Test	**Pre**	23.6±2.6	25.46±2.1	-2.71	<0.01
	Post	24.61±2.6	27.27±1.7	-4.11	<0.01
Triple hop-Distance test(left)	**Pre**	620.66±31.3	636.35±21.4	-2.02	<0.05
	Post	631.9±27.1	654.34±24.3	-3.01	<0.01
Triple hop-Distance test(right)	**Pre**	621.87±27.4	641.53±30.4	-2.34	<0.05
	Post	632.34±26.2	657.05±30.8	-2.98	<0.01
S2P60	**Pre**	11.78±1.3	13.92±1.2	-5.84	<0.01
	Post	13.07±1.2	15.94±1.06	-8.47	<0.01

S3P60	**Pre**	9.78±1.4	11.1±1.4	-3.16	<0.01
	Post	10.78±1.5	12.96±1.05	-5.74	<0.01
	SD: Standard Deviation; *p<0.05 (significant); S2P60: Dynamic two point shooting test in one minute; S3P60: Dynamic three point shooting test in one minute				

The experimental group demonstrated greater improvements across all performance in within the group analysis and between the group analysis variables compared to the control group.

6.DISCUSSION

The findings of the study showed statistically highly significant improvement in upper-limb strength (p<0.001), lower-limb strength (<0.001), vertical jump height (<0.001) and shooting performance S2P60 (<0.001), S3P60 (<0.001) within the group and between the group in both the groups which underwent the Complex training program and plyometric training respectively.

Upper Limb Strength:

The present study demonstrated an increase in upper limb strength in both groups due to an increase in number of push-ups, but when the mean differences of the two groups were compared, the experimental group's performance in the push-up test was superior to that of the control groups, at 4.61 and 3.02, respectively. The maximum strength in the experimental group is more because Complex training combines the post activation potentiation (PAP) induced by high-intensity resistance training and plyometrics.(Carter & Greenwood, n.d.)

Lower limb Strength:

The triple hop distance test in the current study showed an increase in lower limb strength in both groups, but similarly when the mean differences of the two groups were compared, it was found that the EG had outperformed the CG. As the former scored 15.51 for right leg and 17.98 for left leg, whereas the latter's scores were 10.47 for right leg and 11.23 for left leg. This is because high intensity muscle contractions, send continuous signals and stimulate the CNS leading to increase in motor unit recruitment therefore increasing neuromuscular force.(Güllich & Sehmidtbleicher, n.d.) Post activation potentiation is elicited by the resistance training which is also a part of the complex training as discussed above. That's why the experimental group outperformed the control group.

Jumping Performance

The inclusion of exercises like front squats, back squats, depth jumps, spike jumps, etc. place greater demands and effect on quadriceps muscle responsible for generation of power during the test. Greater muscular strength could potentially contribute to improved motor unit recruitment during plyometrics exercises like depth jumps, which would increase training benefits. The current study employed complex training, and the stress placed on the muscles was comparable to that in other investigations, which led to an increase in muscular power levels.(Seitz & Haff, 2016) Significant difference was detected within both the groups with a mean difference of -1.80 in EG and -1.01 in CG but, since both groups engaged in training, which could be the cause of increased jump height, there was slight significance detected between the groups.

Shooting Performance:

The analysis of findings showed that the experimental group better than the control group when shooting performance was compared. Resulted mean difference for S2P60 was 2.01 in the EG and 1.29 in the CG. For S3P60, the mean difference was 1.86 in the EG and 0.99 in the CG. The release height is directly influenced by jump height and player's height. Additionally, increased jump height leads to a subsequent increase in release angle, leading to a greater release height thus improving stability. Releasing the ball at the peak of the jump minimizes vertical velocity, enhancing the player's accuracy in executing the shot. Complex training, as mentioned earlier, increases upper limb strength, which is directly linked to release velocity. This factor is crucial for effectively executing three-point shots.(Behm et al., 2017)

7.LIMITATIONS

The sample size taken for the study was relatively small, and the duration of the protocol implemented was short to ensure the long-term benefit of the training. There is an essential need to replicate these findings with larger sample sizes and longer intervention periods to further validate the efficacy of complex training in basketball players.

8.CONCLUSIONS

The study concluded that complex training, which integrates resistance exercises with plyometric exercises, can significantly improve muscular strength and functional performance in basketball players.

The observed enhancement in the strength of basketball players in the experimental group in this study can potentially be attributed to neural adaptations. These findings have significant implications for the training and conditioning practices in basketball. Coaches and trainers can incorporate complex training exercises into the regular training regimen of basketball players to optimize their physical performance on the court. By enhancing muscular strength and functional capabilities, basketball players can improve their overall athleticism, agility, and game-specific skills.

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AUTHOR CONTRIBUTIONS
Deepak Kumar: Conceptualization, Data curation, Investigation, Methodology, Project administration, Resources
Ankita Saraswat: Software, Validation, Writing – original draft, Writing – review & editing

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Data Availability Statement
Upon reasonable request, the data can be obtained from the corresponding author.

Conflicts of Interest
Authors of this study declares that there is no conflict of interest.

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