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Article

The biomechanical mechanism of muscle strength and explosive power enhancement in college basketball training

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Abstract: Muscle strength and explosive power (EP) are essential attributes for basketball players, enabling them to perform jumping, sprinting, and speed or velocity changes. This research investigated the biomechanical mechanisms of EP and muscle strength enhancement in college basketball players by evaluating the effects of RT, PT, and combined (RT + PT) training methods. Two hundred and fifty male college basketball players were randomly allocated to four categories: G1 (Control), G2 (RT), G3 (PT), and G4 (RT + PT). The intervention lasted 8 weeks with training sessions occurring twice per week. The RT group performed resistance exercises (e.g., squats, deadlifts), the PT group conducted plyometric exercises (e.g., jump squats, box jumps), and the RT + PT group combined both approaches with one session of RT and one session of PT each week. The Control group did not engage in any structured training. Pre- and post-intervention assessments included VJH, 1RM squat strength, 10-meter sprint time (TST), SLHD, and IAT, with limb symmetry assessed using the symmetry angle. All intervention groups (RT, PT, RT + PT) showed significant improvements in VJH, 1RM squat strength, TST, SLHD, and IAT performance ($p < 0.05$) compared to the Control group. However, no significant differences were observed between the RT, PT, and RT + PT groups regarding performance gains. The findings suggest that RT, either alone or combined with plyometric training, should be prioritized to optimize strength, power, and limb coordination in basketball players.

Keywords: explosive power (EP) enhancement; muscle strength; biomechanical mechanism; basketball players; resistance training (RT); plyometric training (PT)

1. Introduction

The biomechanical mechanism of muscular strength pertains to the intricate physiological mechanisms that enable muscular to generate energy and execute diverse actions. Muscle strength is essentially impacted by the shape and function of muscle fibers, as well as neurological regulatory processes that regulate muscle contractions [1]. Muscle fibers contract microscopically using the movement of the filament assumption, in which filaments made of myosin and actin cooperate to generate energy. The effectiveness of this technique is determined by variables such as fiber substance, muscle cross-sectional area, and the nervous system's capacity to acquire muscles [2]. This factor is generally applicable to athletic movement especially to such games as basketball for corresponding sudden leaps of velocity, sudden changes of direction of movement, and random bursts of velocity during the game [3]. Increasing explosiveness can dramatically increase college basketball players' ability to perform high-intensity activities like throwing, blocking shots, and sprinting across the court. The exercise program focuses on building fast-twitch muscle fibers, which are responsible for straight rapid movements [4]. Muscle power training, bounds, and specific athletic movements prepare athletes to have improved jump, quickness, and flexibility. EP training enhances performance depending on the strength and acceleration of a collection, as well as valuable input towards a team's performance [5]. As a consequence, comprehending and using focused EP training approaches is critical for college basketball organizations seeking to maximize player potential and entire team achievement.

Neurological and chemical patterns along with physiological in strong muscles and explosiveness besides functional and athletic are biomechanical mechanisms. Muscle strength is understood as the maximal force that a specific group of muscles can generate [6]. Muscle fiber growth, especially fibers with fast twitch, as well as brain modifications, is critical for increasing strength and power. Furthermore, biomechanics parameters such as force transmission efficiency through connective tissues, joint mechanics, and muscle length-tension connections perform an important impact [7]. Resistance training, plyometrics, and sport-specific workouts all address biomechanical principles to improve muscle activation, tendon flexibility, and energy transfer, resulting in increased strength and explosive power. Understanding these processes is critical for developing successful training plans and improving performance in sports and rehabilitation contexts [8]. More specifically, core muscular treatment requires biomechanical necessity of training lower limbs and the abdominal muscle to enhance the efficiency of the treatment process and minimize the rate of injury [9]. It is necessary for the immovability and accessibility, and provides momentum transfer during the sports motions. The nine exercises incorporating ballistic movements most often incorporate weight application through limb motion in core-intensive activities. These workouts afford the metabolic and biomechanics advantages as tends to prepare different types of sports [10]. The research intends to investigate the biomechanical factors that lead to improve muscular strength and EP during collegiate basketball training. It requires to development of effective training programs that enhance athletic performance while lowering the risk of injury in basketball players.

Research contribution

- The aims to quantify the effects of RT, PT, and their combination (RT + PT) on MS and EP in college basketball players, and the relative benefits of either approach to improving outcomes.
- The research focus on training methods that affect the biomechanical features of the basketball play and includes crucial assessments like VJH, 1 RM squat strength, sprint timing and agility.
- The research aimed at disclosing the advantages of RT for increasing muscular strength and EP in basketball players. It uses the balancing angle to evaluate limb coordination, a unique tool for assessing the effectiveness of different training strategies in enhancing balance and coordination.
- This research emphasizes the significance of RT and PT training in college basketball programs to improve their athletic abilities while reducing injury risk.

Research organization: Section 2 illustrated the literature survey of the research. Section 3 described the Materials and Methods of the research. Section 4 explains the results and discussion of the research. Section 5 determined the research conclusion.

2. Literature survey

The research examined the impacts of UT and BT distinction education on collegiate basketball players' subordinate limb explosiveness, agility, and balance [11]. While UT training enhanced change-of-direction ability and explosive power, BT training was more successful in 1RM, and CMJ, while both groups observed improvements in performance indicators. Research [12] evaluated UT, BT, and combined plyometric activities influenced the physical strength, power, and capacity to shift the direction of young male basketball players. According to the results, UT, BT, and combined (UBT) all considerably enhanced results; however, BT increased asymmetries while UT and UBT decreased them. Additionally, UT enhanced measures of asymmetry, indicating that potency and training coaches should employ UT to maximize the strength and coordination of each specific limb.

In several biomechanical planes, [13] investigated the potentiation impact of conditioning activities on HVM. Four intervention sessions were conducted on male collegiate athletes: two with a biomechanically similar CA, one with a biomechanically different CA, and one without a potentiation warm-up. In a transverse plane HVM, force-velocity measurements showed a notable rise in force variables in the lead and back legs. Assessed how well training techniques worked to lessen basketball players' lower limb strength and explosiveness imbalances [14]. A control group and an intervention group were assigned to thirty male athletes. The experimental groups underwent a 10-week unilateral compound exercise regimen that included explosive and strength training. The program improved standing long jump and double-leg CMJ results, improved isometric mid-thigh pull test metrics, and dramatically decreased asymmetry percentages.

The impact of two plyometric training programs on jump height and leg muscle strength in 29 male basketball players was analyzed in the research [15]. The KF group conducted explosive leaps from 50 cm boxes with the KF, whereas the KE team performed jumps from 30 cm boxes with the KE. Jumping ability was evaluated using SJs, CMJ, and drop jumps. The KF group increased SJs and CMJ but decreased DJ40 height. The KE group increased DJ20 and DJ40 but decreased SJ height. Ankle flexion flexibility improved in the KE subgroup. The impact of accentuated eccentric loaded back squats on youth athletes' post-activation performance enhancement in three jump conditions: CMJ, SJs, and propulsive-only jump [16]. Results showed a considerable enlargement in POJ and jump height JH show at 9 min, while CMJ and SJ performance did not show significant changes. Research suggested that boys high school basketball players can achieve advanced jump performance at 9–12 min post-supramaximal AEL reverse squat.

The horizontal and vertical leaps of top-tier male basketball players from Taiwan who underwent a 12-week axial stabilisation training program were examined [17]. The intervention group performed twice a week, while the control group received general basketball training. The research found that the training program improved lateral jump performance, with steeper kurtosis, shorter jump time, increased GRF, and longer passage duration. The link between FFM, CMJ influence, and highest hamstrings pressure in female basketball practitioners was investigated [18]. There were strong relationships between FFM and hamstring pressure across both legs, as well as strength and jump elevation. These findings suggested FFM and power are crucial for enhancing performance and reducing injury risk.

The differences between aided and resisted sprint training techniques for enhancing athletes' biomechanical efficiency, speed, and acceleration are examined [19]. While resisted training concentrates on building strength and power, assisted training lessens resistance during sprints. Although their working processes are different, both strategies improve sprint performance. While resisted training concentrates on strength and power, assisted training increases. Comprehending these distinctions was essential for maximizing training plans and reducing the likelihood of injuries. Research in Sichuan Province, China, found that personalized nutritional support and monitoring during pre-competition weight reduction significantly improved female weightlifters' competitive state [20]. The intervention group had decreased creatine Kinase levels, increased testosterone, testosterone/cortisol ratio, and hemoglobin levels, decreased tiredness, and improved quality sleep. Incorporating biochemistry diagnostics and individualized nutritional supplementation was an important method for improving female weightlifters' competitive performance.

Specialized physical training techniques for sports dancing athletes at universities in Hebei Province are examined by research [21]. Finding flaws in existing training approaches suggests a customized program that emphasizes fundamental skills including coordination, strength, endurance, and flexibility. Additionally, a scientific monitoring system for timely modifications and athlete growth was established by the research. Research [22] was undertaken to notice the association and create a regression analysis of those variables. Techniques: Eleven (n = 11) adult male basketball players from Guru Nanak Dev University in Amritsar, who were split into two groups, participated in the research. Before their involvement, they were all told about the research's goal, risks, and benefits, and their agreement was acquired following the Helsinki Declaration. They provided baseline information for aerobic (metabolic) data, counter-movement jumps, and 30-second Wingate Anaerobic Exercise. Research [23] involved 40 participants divided into four groups showed that the PSG showed the largest increase in comparative highest torque throughout isokinetic assessment of the shoulders and knee components. All training categories improved overall endurance, sprint achievement, 1RM, and core muscle biomechanics, with PSG exhibiting the greatest increase in externally transverse rigidity.

The effects on lower-body strength in collegiate athletes are examined in the investigation [24]. Nineteen individuals were distributed at random to either group, and both participated in a 6-week intervention that included twice-weekly training sessions. Basketball is a tremendously active activity that requires a lot of jumping, frequent pace changes, and vigorous use of every muscle group. The goal of the investigation [25], evaluate and clarify the important factors that contribute to basketball athletes' improvement in explosive power. To program training for fostering the growth of explosive power, it is required to ascertain the training load, techniques, and regularity during the various stages of sports preparation. The most crucial aspect of differentiation for athletes is their age. The development of quickness must receive a lot of attention since it is a useful tool that increases a basketball player's productivity. The research's combining of time-motion assessment and recuperation procedures yielded important insights into player performance and well-being. It also emphasized the benefits of combining both mental and physical training approaches, which improve decision-making abilities and overall game performance. The entire method provided a sophisticated knowledge of basketball learning, resulting in improved player performance and well-being.

Research gap

A significant gap in the biomechanical mechanism of muscle strength in college basketball training lies in the limited understanding of how specific training protocols affect the dynamic interaction between muscle groups during high-intensity movements such as jumping and sprinting. While numerous studies have investigated the impact of strength training on muscle hypertrophy and performance, there is a lack of comprehensive analysis regarding how different training methods, such as plyometric exercises, resistance training, and sport-specific drills, influence neuromuscular adaptations in athletes at the collegiate level. Furthermore, the interaction between force output, muscle recruitment, and movement kinematics has not been studied adequately. Filling this gap could assist in establishing more ideal training programs to develop physical college basketball players with regards to the aspect of EP with less risk of injury offer a predominant approach towards training intervention for the college basketball players.

3. Methods and materials

The biomechanical processes behind the development of strength in muscles and EP during college basketball training are explored. By using a control and intervention design, it assesses the effects of a specialized strength and conditioning program, combining plyometric exercises and resistance training. Pre- and post-training assessments are conducted through motion capture technology and force plate measurements to analyze improvements in muscle force and the influence of unstable training variables. These training modalities contribute to developing EP and overall strength, vital for performance in basketball, particularly for movements like jumping and sprinting. **Figure 1** denotes the outline of the research.

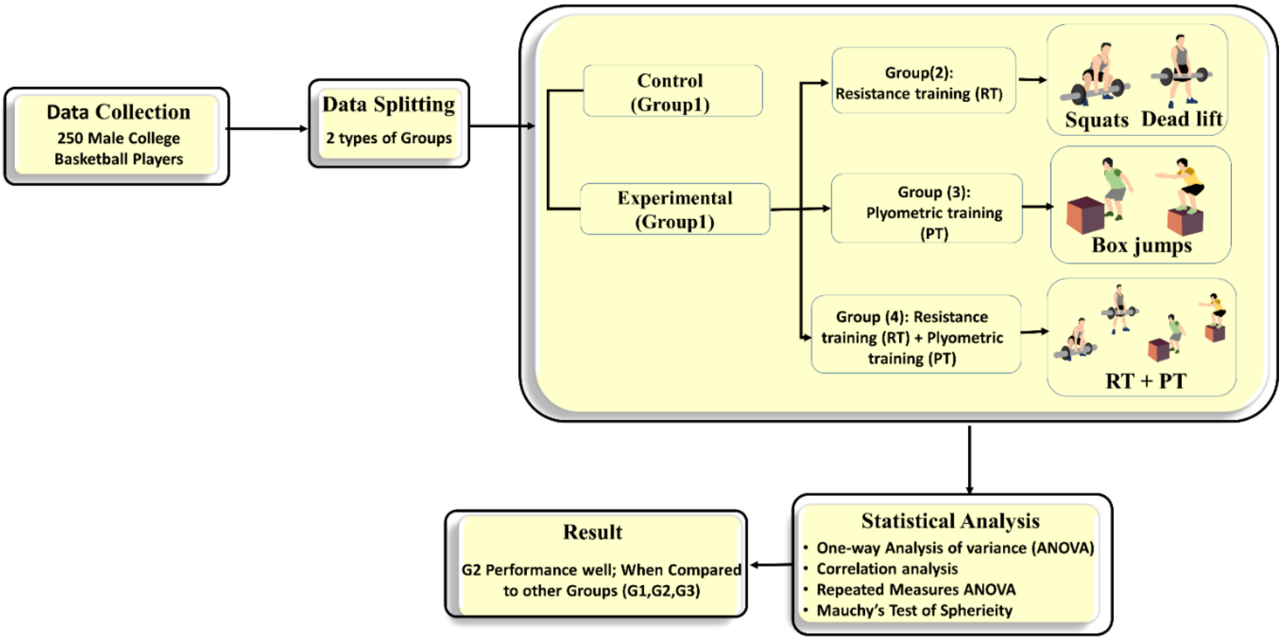

Figure 1. Overview of the research outline.

3.1. Data collection

The biomechanical processes behind the development of strength in muscles and EP during college basketball training are explored, with a total of 250 participants involved. The participants were divided into four groups: a control group (G1) and three experimental groups focusing on different training interventions. The resistance training group (G2), plyometric training group (G3), and a combined resistance and plyometric training group (G4) were assessed for improvements in key performance metrics. The participants were aged 18–23, with varying levels of training experience and sport-specific training hours per week. Key characteristics such as height, body mass, BMI, and injury history were considered in the group composition. To uncover how different training methodologies influence muscle strength and explosive power, which are critical for enhancing athletic performance in basketball.

3.2. Data splitting

The data collected were divided based on the intervention groups: Control group (G1), Resistance Training group (G2), Plyometric Training group (G3), and Combined Resistance and Plyometric Training group (G4). The data collected from these groups were than compared to the pre and post intervention results of each of the above stated performance indicators.

3.2.1. Control Group (G1)

G1 has been used to test the result of training compared to no training. This group did not receive any structured exercise intervention but was assessed on the same metrics to establish baseline measures and serve as a reference for the changes observed in the intervention groups.

3.2.2. Resistance Training (RT) Group (G2)

G2 focuses on improving strength by performing resistance exercises such as squats and deadlifts. The data collected for this group allowed for the evaluation of strength development (1RM squat) and its influence on other performance measures like VJH and TST.

3.2.3. Plyometric Training (PT) Group (G3)

G3 used plyometric exercises, which are designed to enhance EP and agility. Exercises like jump squats and box jumps were included. The data collected here were used to evaluate the effects of plyometric training on explosive power (VJH) and TST and the pattern of hypertrophy of strength and limb coordination.

3.2.4. Combined RT + PT Group (G4)

G4 combined both training approaches by incorporating both resistance training and plyometric exercises. This group was designed to determine if there is an enhanced overall performance when the two training methods are integrated compared to the performance of the single-modality groups especially in strength, explosive power, and co-ordination.

Table 1. Characteristics of Demographic Variables.

Characteristic	Control Group (G1)	Intervention Group (Overall) (*n* = 130)		
		Resistance Training (G2)	Plyometric Training (G3)	RT + PT (G4)
Total Sample Size	120	43	43	44
Age (Years)	18–20	21–23	19–22	19–22
Height (cm)	170–180	170–180	175–190	175–190
Body Mass (kg)	60–75	60–80	65–90	65–90
BMI (kg/m²)	18–22	20–25	21–28	21–28
Training Experience (Years)	0	2–4	2–4	2–4
Sport-Specific Training (hrs/week)	0	5–8	6–9	6–9
Primary Position	Guard/ Forward	Guard/Forward/ Center	Guard/Forward/ Center	Guard/Forward/ Center
Injury History	-	1–3 Injuries	0–1 Injuries	0–1 Injuries

Table 1 outlines the demographic characteristics of the research participants (N = 250). The overall sample size includes 130 participants in the Intervention Group, with 43 in the Resistance Training (G2) group, 43 in the Plyometric Training (G3) group, and 44 in the RT + PT (G4) group. The Control Group (G1) has 120 participants. Participants in G1 are aged 18–20 years, while those in G2 are 21–23 years, and G3 and G4 participants are between 19 and 22 years. G1 and G2 have heights ranging from 170–180 cm, while G3 and G4 participants range from 175–190 cm. The body mass of participants in G1 and G2 ranges from 60–80 kg, while G3 and G4 have a range of 65–90 kg. BMI values are 18–22 for G1, 20–25 for G2, and 21–28 for both G3 and G4. The Control Group (G1) has no reported training experience, whereas G2, G3, and G4 participants have 2–4 years of training experience. The sport-specific training hours per week are 0 for G1, 5–8 for G2, and 6–9 for G3 and G4. The primary positions are Guard, Forward, and Center across all groups. G2 participants have 1–3 injuries, while G3 and G4 participants have 0–1 injuries. The intervention groups have varied ages, body compositions, training histories, and injury histories,

which could potentially affect the results of performance outcomes in basketball training. This research data is assessed at two instance points: pre-intervention and post-intervention. The participants were assessed on various performance metrics to evaluate the production of the different training methods on muscle strength and explosive power.

The measures included the VJH to assess explosive power, the 1RM squat strength to evaluate maximal strength, the 10-meter TST for speed, the SLHD for lower body coordination, and the IAT for assessing limb symmetry. Asymmetry angle was employed to quantify the differences in limb before and after the intervention were compared. All test procedures were administered in a static environment and participants were encouraged to execute the exercises comparably to the previous tests thus minimizing bias.

3.3. Qualitative analysis

The research utilized a randomized controlled design to investigate the effects of different training interventions on muscle strength and EP in college basketball players. The training methods under evaluation were the methods G2, G3, and G4. Participants performed special strength and power exercises including RT squats and deadlifts, PT = jump squats, and box jumps. Pre- and post-intervention assessments were conducted to measure performance improvements across several key variables, including VJH, 1RM squat strength, 10-meter sprint time, single leg hop distance, and agility as assessed by the Illinois agility test.

3.4. Statistical analysis

For data analysis, the control and intervention group pre- and post-intervention data have been compiled and analyzed using SPSS 24.0 software. One Way ANOVA is used to compare the means of several training groups such as Control Training Group, RT Training Group, PT Training Group and Combined Training Group to determine if there exist significant difference in basketball performance outcomes. The Correlation Analysis investigates the correlation between VJH and squat strength between groups and measures the potentials of underlying performance enhancements due to the variation of the training approach. The Repeated Measures ANOVA is a statistical technique used in research to compare changes in performance across time within a group relative to specific variables such as vertical jump height, squat strength, or agility tests to complement the analysis of the main result, Mauchly's Test of Sphericity (MTS) is used to check the suitability of the statistical data.

4. Results

The results of this research provide a thorough analysis of how various training interventions impact basketball performance by incorporating a range of statistical analyses. Demographic analysis offered insight into the participant characteristics, which helps to contextualize the findings. One-way ANOVA is employed to assess the differences between multiple groups receiving different training interventions, revealing significant variations in performance outcomes. Correlation analysis further explored the relationships between training factors and performance metrics, indicating the strength and direction of these associations. Repeated measures of ANOVA were used to track changes over time within the same participants, identifying significant improvements or declines in performance across different training phases. MTS is applied to ensure the validity of the repeated measures ANOVA, confirming that the assumption of sphericity is met for the analysis, thus enhancing the reliability of the findings. Collectively, these analyses provided a comprehensive understanding of the impact of different training methods on basketball performance.

4.1. One-Way ANOVA

The ANOVA method is employed to assess the significant difference between the means of three or more independent groups, such as the effectiveness of different training exercises like basketball shooting accuracy or stamina. One-way ANOVA is used to establish if there are statistically considered differences in basketball performance outcomes between different training methods, as revealed in **Table 2**.

Table 2. Outcomes of One-Way ANOVA.

Group	Shooting Accuracy (%)	Vertical Jump Height (cm)	Endurance (minutes)
G1	65 ± 5	45 ± 3	6.5 ± 0.8
G2	80 ± 4	55 ± 4	8.0 ± 0.7
G3	75 ± 3	50 ± 3	7.0 ± 0.6
G4	78 ± 3	52 ± 3	7.5 ± 0.5
F-Statistic	45.67	38.22	32.58
P-Value	0.001	0.001	0.001

G2 achieves the best outcomes across all performance metrics on muscle strength and EP enhancement in college basketball training. The one-way ANOVA findings indicate substantial differences between the groups ($p < 0.05$). Specifically, G2 outperforms all other groups in shooting accuracy (80% vs. 65% in G1), vertical jump height (55 cm vs. 45 cm in G1), and endurance (8.0 min vs. 6.5 min in G1). G2's superior performance is consistent across all measured attributes, indicating substantial improvements in muscle strength and explosive power. The p-values of 0.001 for each metric confirm that these differences are statistically significant, underscoring the effectiveness of the training or intervention employed in G2 relative to the other groups.

4.2. Correlation analysis

It measures the strength and direction of the relationship between two variables, such as examining how physical fitness levels correlate with performance outcomes like points scored or defensive skills in basketball training. **Table 3** explains the principle of this Correlation Analysis to observe the performance outcomes (VJH, 1RM Squat Strength, TST, SLHD, and IAT) across four groups (G1, G2, G3, and G4) in basketball athletes.

Table 3. Outcomes of correlation analysis of performance.

Group	VJH (cm)	1RM Squat Strength (kg)	TST (s)	SLHD (m)	IAT (s)	Statistical Test (*F*-Statistic)	Statistical Significance (*p*-value)
G1	45.3 ± 3.2	80.4 ± 5.1	10.5 ± 1.2	4.5 ± 0.6	12.5 ± 1.0	N/A	N/A
G2	55.1 ± 4.0	95.2 ± 4.2	9.2 ± 0.9	5.2 ± 0.5	10.7 ± 0.8	36.55	0.001
G3	50.0 ± 3.5	90.1 ± 4.3	9.5 ± 0.8	4.9 ± 0.6	11.2 ± 0.7	40.12	0.001
G4	52.2 ± 3.7	92.4 ± 3.8	9.0 ± 0.7	5.1 ± 0.4	10.9 ± 0.6	29.72	0.001
Overall *F*-Statistic	N/A					42.63	0.001
Post-Hoc Test	G2 > G1, G3, G4		G2 < G1, G3			-	-

By conducting this analysis, determine whether there are significant differences in these performance metrics between the groups, with a focus on identifying which group shows the greatest improvements in athletic performance. Statistical significance ($p < 0.05$) is assessed using F-tests to compare group means. **Figure 2** represents the outcome of the correlation analysis.

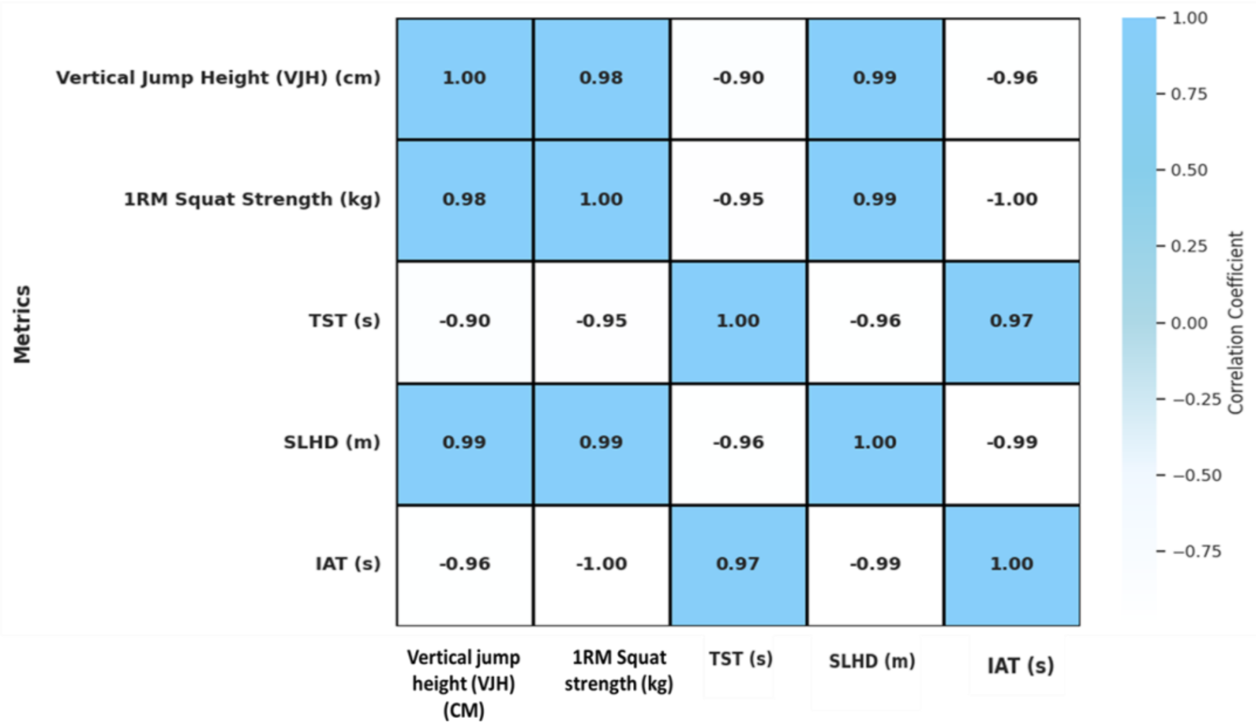

Figure 2. Graphical outcome of the correlation analysis.

In a comparison of four groups (G1, G2, G3, G4) across various performance metrics related to muscle strength and EP enhancement in college basketball training: VJH, 1RM Squat Strength, TST, SLHD, and IAT. The data reveals that G2 consistently outperforms the other groups, showing higher VJH, 1RM Squat Strength, and SLHD, as well as lower TST and IAT scores, indicating superior muscle strength and explosive power. With a *p*-value of 0.001 and an *F*-statistic of 36.55 for G2, statistical analysis using correlation analysis reveals substantial differences across groups, indicating that the observed variations are unlikely to be the result of chance.

The post-hoc test confirms G2's superiority, showing it exceeds the performance of Groups 1, 3, and 4 in several areas. Overall, the results suggest that G2's training approach significantly enhances muscle strength and EP in college basketball athletes.

4.3. Repeated measures ANOVA

Repeated measures ANOVA evaluates changes in performance over time by measuring the same participants under different conditions, like tracking improvements in shooting accuracy or endurance before and after a specific basketball training program, as represented in **Table 4**. The repeated measures ANOVA aims to track the performance changes across multiple time points within each intervention group G1, G2, G3, and G4, and determine the significance of these changes. It assesses how the intervention impacts performance VJH, 1RM Squat Strength, TST, SLHD, and IAT over time.

Table 4. Repeated measures ANOVA of performance over time.

Group	Pre-Test Mean	Post-Test Mean	Change (Post-Pre)	*F*-Statistic	*p*-value
G1	45.3	47.0	1.7	1.25	0.32
G2	45.3	58.2	12.9	42.63	0.001
G3	45.5	52.4	6.9	23.45	0.001
G4	45.7	53.6	7.9	30.22	0.001

Four distinct groups (G1, G2, G3, and G4) participated in a college basketball training intervention aimed at improving muscular strength and explosive power. G1 showed a minimal change in strength and power (1.7 points), with an F-statistic of 1.25 and a *p*-value of 0.32, indicating no significant improvement. In contrast, Groups 2, 3, and 4 exhibited considerable improvements: G2 improved by 12.9 points ($p = 0.001$), G3 by 6.9 points ($p = 0.001$), and G4 by 7.9 points ($p = 0.001$). All three groups had statistically significant results, with *p*-values below 0.05, suggesting that the training intervention was effective in improving muscle strength and EP for these groups.

4.4. Mauchly's Test of Sphericity (MTS)

Table 5. MTS findings.

Group	Chi-Square Value	DF	*p*-value
G1	5.63	2	0.059
G2	1.42	2	0.494
G3	4.07	2	0.131
G4	3.89	2	0.142

Mauchly's test checks whether the assumption of sphericity is met in Repeated Measures ANOVA, ensuring that the variances of differences across conditions are equal, which affects the validity of the results. The purpose of MTS is to check whether the assumption of sphericity with equal variances of the differences between conditions holds in repeated measures data. A violation of sphericity indicates that adjustments are needed for the degrees of freedom (DF) in subsequent statistical tests. It guarantees adhesive to the assumptions required before conducting the Repeated Measures ANOVA test (**Table 5**).

MTS for four groups (G1, G2, G3, and G4) on muscle strength and EP enhancement in college basketball training. The Chi-Square values and corresponding *p*-values for each group are provided, along with the DF, which is 2 for all groups. For G1, the *p*-value is 0.059, which is marginally above the typical 0.05 significance threshold, indicating weak evidence but not statistically significant. For G2, G3, and G4, the *p*-values are 0.494, 0.131, and 0.142, respectively, all greater than 0.05, suggesting no significant association between the variables in these groups. Overall, none of the groups show a statistically significant result, indicating that the observed and expected frequencies do not differ significantly in the context of muscle strength and EP training.

5. Discussion

The research examines the biomechanical mechanisms responsible for enhancing strength and EP in college athletes by comparing the effects of four different intervention groups (G1, G2, G3, and G4). The demographic analysis of the participants revealed variability in factors such as age, body composition, and injury history, all of which could influence the performance outcomes of the groups. One-way ANOVA analysis showed that G2 consistently outperformed all other groups in key performance metrics such as shooting accuracy, VJH, and endurance, with statistically significant differences ($p < 0.001$). Further, the correlation analysis demonstrated that all intervention groups, particularly G2, showed significant improvements compared to G1, confirming the effectiveness of the training interventions. Repeated Measures ANOVA tracked performance changes over time, revealing that G2 exhibited the most substantial improvement in VJH, with an F-statistic of 42.63 ($p = 0.001$). While G3 and G4 also showed significant gains in performance, particularly in endurance and jump height, G2 remained the most effective intervention for enhancing explosive power. However, MTS revealed that adjustments were needed for the data analysis due to violations of sphericity in G1, G2, G3, and G4. It highlights the importance of correcting for statistical assumptions when analyzing repeated measures data. The superior effectiveness of G2 in improving athletic performance, although G3 and G4 also provide meaningful benefits, especially for endurance and EP development.

6. Conclusion

The biomechanical mechanisms of enhancing the strength of muscles and forcefulness in college basketball players through G2, G3, and a combined G4 approach. Results showed significant improvements in key metrics, but no significant differences in magnitude. The investigation employed demographical analysis, One-Way ANOVA, correlation analysis, MTS, and Repeated Measures ANOVA to comprehensively evaluate the effects of different training interventions on basketball performance outcomes. One-way ANOVA revealed significant differences in performance ($p < 0.001$), with the G2 group outperforming the other groups in shooting accuracy (80%), VJH (55 cm), and endurance (8.0 min). Correlation analysis further highlighted the improvements, with G2 showing the best results in VJH (55.1 cm), 1RM squat strength (95.2 kg), and endurance (10.7 *s*), all with significant *p*-values (< 0.001). Repeated measures ANOVA demonstrated that G2 experienced the highest improvement in vertical jump height (+12.9 cm, $F = 42.63$, $p = 0.001$), followed by G4 (+7.9 cm), G3 (+6.9 cm), and G1 (+1.7 cm). MTS indicated violations of sphericity for the G1, G3, and G4 groups, though the Resistance Training group did not violate this assumption ($p = 0.494$). These results suggest that G2's training regimen had the most substantial impact on performance, particularly in strength and endurance metrics, though overall magnitude differences between approaches were minimal. The limitations include, short intervention period, absence of female participants, and the selection of only certain performance indicators thus and restricted to such indicators and cannot be generalized to a variety of athletes. Future scope should assess training for more extended periods of time, both the direct and indirect effects of RT & PT integration, more varied subjects, biomechanics, neuromuscular changes, recovery, and changes in training volume on performance and injury risk.

Ethical approval: Not applicable.

Conflict of interest: The author declares no conflict of interest.

Abbreviations

EP	Explosive Power
RT	Resistance Training
PT	Plyometric Training
VJH	Vertical Jump Height
1RM	1-Repetition Maximum
SLHD	Single-Leg Hop Distance
IAT	Illinois Agility Test
CMJ	Countermovement Jump
UT	Unilateral
BT	Bilateral
UBT	Combine Unilateral and Bilateral
HVM	High Velocity Movement
CA	Conditioning Activity
KE	Knee-Extended
PSG	Pyramid Set Training Group
KF	Knee-Flexed
GRF	Ground Reaction Force
AEL	Accentuated Eccentric Loaded
SJs	Squat Jumps
POJ	Propulsive-Only Jump
FRST	Fly Wheel Resistance Squat Training

TRST	Traditional Resistance Squat Training
RSI	Reactive Strength Index
JH	Jump Height
FFM	Fat-Free Mass
DF	Degrees of Freedom
MTS	Mauchly’s Test of Sphericity

References

1. Abuwarda, K. and Akl, A.R., 2024. Assessment of trunk and shoulder muscle asymmetries during two-armed kettlebell swings: implications for training optimization and injury prevention. Frontiers in Sports and Active Living, 6, p.1497826. https://doi.org/10.3389/fspor.2024.1497826
2. Wang, B., Xie, E., Liang, P., Liu, T., Zhu, J., Qin, G. and Su, X., 2024. Transforming performance: The impact of an 8-week complex training program on strength, power, and change of direction in female basketball athletes. Medicine, 103(24), p.e38524. https://doi.org/10.1097/MD.0000000000038524
3. Liu, Y., 2022. A Research on the Importance of Core Strength and Coordination Balance during Basketball Based on Biomechanics. Molecular & Cellular Biomechanics, 19(3). https://doi.org/10.3389/fphys.2024.1427291
4. Al Kitani, M., 2024. The effect of neuromuscular training on improving some skill performances in basketball. Journal of Physical Education, 36(1). https://doi.org/10.37359/JOPE.V36(1)2024.2061
5. Wang, J., Li, C. and Zhou, X., 2024. Decoding the court: Insights into basketball training and performance optimization through time-motion analysis. Education and Information Technologies, pp.1-30. https://doi.org/10.1007/s10639-024-12783-z
6. Wang, X., 2024. Biomechanical Analysis on the In-situ Three-point Jump Shooting Technique in Basketball. In Sustainable Materials Processing and Manufacturing (pp. 1-6). CRC Press. https://doi.org/10.3389/fspor.2023.1304911
7. Aouichaoui, C., Tounsi, M., Racil, G., Tabka, O., Zaouali, M., Bragazzi, N.L. and Trabelsi, Y., 2024. Age-and Gender-Specific Reference Values for Physical Performance in Tunisian Youth Basketball Players. Children, 11(11), p.1346. https://doi.org/10.3390/children11111346
8. ZAMBAK, Ö. and TOKTAŞ, S., 2024. The Effect Of Plyometric Training On The Anaerobic Power Of Basketball Players Training In Private College. International Journal of Eurasian Education and Culture, 9(27), pp.377-387. http://dx.doi.org/10.35826/ijoecc.2839
9. Pan, H., Li, J., Wang, H. and Zhang, K., 2021, September. Biomechanical analysis of shooting performance for basketball players based on computer vision. In Journal of Physics: Conference Series (Vol. 2024, No. 1, p. 012016). IOP Publishing. https://doi.org/10.3390/app14135742
10. Hassan, A.K., Bursais, A.K., Alibrahim, M.S., Selim, H.S., Abdelwahab, A.M. and Hammad, B.E., 2023. The impact of core complex training on some basketball-related aspects of physical strength and shooting performance. European Journal of Investigation in Health, Psychology and Education, 13(9), pp.1624-1644. https://doi.org/10.3390/ejihpe13090118
11. Duan, T., He, Z., Dai, J., Xie, L., Shi, Y., Chen, L., Song, J., Li, G. and Zhang, W., 2024. Effects of unilateral and bilateral contrast training on the lower limb sports ability of college basketball players. Frontiers in Physiology, 15, p.1452751. https://doi.org/10.3389/fphys.2024.1452751
12. Cao, J., Xun, S., Zhang, R. and Zhang, Z., 2024. Effects of Unilateral, Bilateral and Combined Plyometric Jump Training on Asymmetry of Muscular Strength and Power, and Change-of-Direction in Youth Male Basketball Players. Journal of Sports Science & Medicine, 23(4), p.754. https://doi.org/10.52082/jssm.2024.754
13. Parks, A., 2024. Is There a Post-Activation Performance Enhancement of a Conditioning Activity on a High-Velocity Movement in a Different Biomechanical Plane of Motion? https://doi.org/10.57709/36938439
14. Zhang, W., Chen, X., Xu, K., Xie, H., Chen, J., Zhu, Z., Ji, H., Li, D. and Sun, J., 2024. The potential of a targeted unilateral compound training program to reduce lower limb strength asymmetry and increase performance: a proof-of-concept in basketball. Frontiers in Physiology, 15, p.1361719. https://doi.org/10.3389/fphys.2024.1361719
15. Pechlivanos, R.G., Amiridis, I.G., Anastasiadis, N., Kannas, T., Sahinis, C., Duchateau, J. and Enoka, R.M., 2024. Effects of plyometric training techniques on vertical jump performance of basketball players. European Journal of Sport Science. https://doi.org/10.1002/ejsc.12097

16. Ditch, J.C., 2024. Acute Potentiation on Vertical Jump Performance Following Accentuated Eccentric Loaded Back Squats in Male High School Basketball Players.
17. Huang, W.Y., Huang, H. and Wu, C.E., 2024. Differences in the Lateral and Vertical Jump Performances of Elite Male Basketball Players, An Axial Stabilization Training Program. Applied Sciences, 14(11), p.4832. https://doi.org/10.3390/app14114832
18. Budijono, A.P., Siantoro, G., Dhenabayu, R., Hartoto, S., Kusuma, D.A., Firmansyah, A., Prasetya, M.R.A. and Garcia-Jimenez, J.V., 2024. Determining the Correlation of Fat-Free Mass, Power, and Maximum Hamstring Force in Female Basketball Athletes. Physical Education Theory and Methodology, 24(6), pp.892-897. https://doi.org/10.17309/tmfv.2024.6.05
19. Jogi Prasad, D.A., 2024. Comparative Analysis of Assisted vs. Resisted Sprint Training: Effects on Acceleration, Speed, and Biomechanical Efficiency in Athletes. Library Progress International, 44(3), pp.11431-11438.
20. Yu, L. and Cheng, L., 2024. Enhancing performance through biochemical monitoring and nutritional support in female weightlifters during pre-competition weight reduction: a randomized trial. Journal of the International Society of Sports Nutrition, 21(1), p.2435542. https://doi.org/10.1080/15502783.2024.2435542
21. Ma, Z., Han, X., Li, M., Li, X. and Kong, Y., Research on Specialized Physical Training for Sports Dance Athletes in Hebei Province's Universities. https://doi.org/10.25236/FSR.2024.060602
22. Thakral, R., Pramanik, A. and Kumar, H., 2025. Comparison of Selected Biomechanical and Physiological Variables Among Novice and Experienced University Basketball Athletes. In International Conference of the Indian Society of Ergonomics (pp. 123-132). Springer, Singapore. https://doi.org/10.1007/978-981-97-7804-113
23. Liu, P., Yuan, H., Lu, Y. and Gao, Z., 2024. Resistance training modalities: comparative analysis of effects on physical fitness, isokinetic muscle functions, and core muscle biomechanics. Frontiers in Physiology, 15, p.1424216. https://doi.org/10.3389/fphys.2024.1424216
24. Xie, L., Qu, W., Dai, J., Xu, J., Zhang, W., Sun, J., Song, W. and Li, D., 2024. The impact of flywheel resistance squat training on lower limb strength in female college basketball players. Frontiers in Physiology, 15, p.1491957. https://doi.org/10.3389/fphys.2024.1491957
25. Aksović, N., Bjelica, B., Milanovi, F., Milanovic, L., Jovanović, N., 2021. Development of explosive power in basketball players. Turkish Journal of Kinesiology, 7(1):44-52. https://doi.org/10.31459/turkjkin.861920