Effects of Different Load Squatting on Lower Limb Explosive Power, Knee Joint Isokinetic Muscle Strength, and Serum Biochemical Parameters in Non-professional Male College Basketball Players

Gu Kenan, Song Yanliqing, Liu Xueqian, Niu Xiaoqian

2026-08-10
ChinaRxiv

Abstract

Objective To reveal the effects of squats with different loads on lower-limb explosive power, knee isokinetic muscle strength, and serum biochemical parameters in non-professional male college basketball players. Methods Thirty-six non-professional male college basketball players were selected as the study participants and randomly divided into a 70% 1-repetition maximum load (1repetitionmaximum, 1RM) group, an 80% 1RM group, and a 90% 1RM group (n=12). Constant-load back squat strength training was performed at 70% 1RM, 80% 1RM, and 90% 1RM, respectively. Training was conducted twice per week for 8 weeks. Lower-limb explosive power indicators, knee isokinetic muscle strength, and serum biochemical parameters were measured before and after training. Results The standing vertical jump reach performance of the 80% 1RM group was significantly higher than that of the 70% 1RM group and the 90% 1RM group (P<0.05, statistically significant); the standing long jump performance of the 80% 1RM group was significantly higher than that of the 90% 1RM group (P<0.05). The peak torque of knee extension at 60°/s in the 90% 1RM group was significantly higher than that in the 70% 1RM group and the 80% 1RM group (P<0.05); the peak torque of knee flexion at 180°/s in the 80% 1RM group was significantly higher than that in the 70% 1RM group and the 90% 1RM group (P<0.05). The lactic acid (lacticacid, LA) clearance rate and testosterone (testosterone, T) level in the 80% 1RM group were significantly higher than those in the 70% 1RM group and the 90% 1RM group (P<0.05); creatine kinase (creatinekinase, CK) and cortisol (cortisol, Cor) in the 90% 1RM group were significantly higher than those in the 70% 1RM group and the 80% 1RM group (P<0.05). Conclusion The effects of 8 weeks of squat training with different loads on non-professional male college basketball players showed load specificity. The 80% 1RM group had the best overall effects on lower-limb explosive power, rapid contraction ability, and metabolic and anabolic hormone regulation; the 90% 1RM group was more conducive to improving maximal knee extensor strength but was accompanied by greater muscle damage and stress responses, while the 70% 1RM group showed weaker effects.

Full Text

Effects of Different Load Squatting on Lower Limb Explosive Power, Knee Joint Isokinetic Muscle Strength, and Serum Biochemical Parameters in Non-professional Male College Basketball Players

Gu Kenan^1, Song Yanliqing^1, Liu Xueqian^2, Niu Xiaoqian^3

(1. School of Physical Education, Nanjing Tech University, 211816 Nanjing; 2.

Taicang Affiliated Hospital of Nanjing University of Chinese Medicine, 215400 Nanjing;
3. School of Continuing Education, Nanjing University of Media and Communications, 211172 Nanjing)

Abstract: Objective To reveal the effects of squat training with different loads on lower limb explosive power, knee joint isokinetic muscle strength, and serum biochemical parameters in non-professional male college basketball players. **Methods** Thirty-six non-professional male college basketball players were selected as the study subjects and randomly divided into a 70% 1-repetition maximum (1 repetition maximum, 1RM) group, an 80% 1RM group, and a 90% 1RM group ($n = 12$). Squat strength training was performed using constant loads of 70% 1RM, 80% 1RM, and 90% 1RM, respectively. Training was conducted twice per week for a total of 8 weeks. Lower limb explosive power indices, knee joint isokinetic muscle strength, and serum biochemical parameters were measured before and after training. **Results** The standing vertical-jump performance of the 80% 1RM group was significantly higher than that of the 70% 1RM group and the 90% 1RM group ($P < 0.05$, statistically significant); the standing long-jump performance of the 80% 1RM group was significantly higher than that of the 90% 1RM group ($P < 0.05$). The knee-extension 60°/s peak torque of the 90% 1RM group was significantly higher than that of the 70% 1RM group and the 80% 1RM group ($P < 0.05$); the knee-flexion 180°/s peak torque of the 80% 1RM group was significantly higher than that of the 70% 1RM group and the 90% 1RM group ($P < 0.05$). The lactate acid (LA) clearance rate and testosterone (T) level of the 80% 1RM group were significantly higher than those of the 70% 1RM group and the 90% 1RM group ($P < 0.05$); creatine kinase (CK) and cortisol (Cor) in the 90% 1RM group were significantly higher than those in the 70% 1RM group and the 80% 1RM group ($P < 0.05$). **Conclusion** Eight weeks of squat training with different loads produced load-specific effects in non-professional male college basketball players. The 80% 1RM group showed the best overall effects on lower limb explosive power, rapid contractile ability, and regulation of metabolic and anabolic hormones. The 90% 1RM group was more conducive to improving maximal knee-extensor strength but was accompanied by stronger muscle damage and stress responses, while the 70% 1RM group showed weaker effects.

Keywords: squat; load; college students; male basketball players; lower limb explosive power; isokinetic muscle strength; biochemical parameters

Chinese Library Classification No.: O39; G804.6 **Document code:** A **DOI:** 10.11776/j.issn.1000-4939.2026.04.021

Article No.: 1000-4939(2026)04-0959-08 **CSTR:** 32414.14.cjam.issn.1000-4939.2026.04.021

Effects of different load squatting on lower limb explosive power, knee joint isokinetic muscle strength and serum biochemical parameters in non-professional male college basketball players

Gu Kenan^1, Song Yanliqing^1, Liu Xueqian^2, Niu Xiaoqian^3

Date received: 2026-01-15
Funding project: Jiangsu Higher Education Philosophy and Social Science Research Fund Project (No. 2023SJYB0221)
Corresponding author: Song Yanliqing. E-mail: 13813800961@163.com
Citation format: Gu Kenan, Song Yanliqing, Liu Xueqian, et al. Effects of different load squatting on lower limb explosive power, knee joint isokinetic muscle strength and serum biochemical parameters in non-professional male college basketball players[J]. *Chinese Journal of Applied Mechanics*, 2026, 43(4): 959-966.

Gu Kenan, Song Yanliqing, Liu Xueqian, et al. Effects of different load squatting on lower limb explosive power, knee joint isokinetic muscle strength and serum biochemical parameters in non-professional male college basketball players[J]. *Chinese Journal of Applied Mechanics*, 2026, 43(4): 959-966.

(1. School of Physical Education, Nanjing University of Technology, 211816 Nanjing, China;
2. Taicang Affiliated Hospital of Nanjing University of Traditional Chinese Medicine, 215400 Nanjing, China;
3. School of Continuing Education, Nanjing University of Media & Communications, 211172 Nanjing, China)

Abstract: Objective To reveal the effects of squatting with different loads on lower-limb explosive power, knee-joint isokinetic muscle strength, and serum biochemical parameters in non-professional male college basketball players. **Methods** Thirty-six non-professional male college basketball players were selected as subjects and randomly divided into a 70% one-repetition maximum (1RM) group, an 80% 1RM group, and a 90% 1RM group, with 12 subjects in each group. They performed back-squat strength training with constant loads of 70% 1RM, 80% 1RM, and 90% 1RM, respectively. Training was conducted twice a week for a total of 8 weeks. Lower-limb explosive-power indicators, knee-joint isokinetic muscle strength, and serum biochemical parameters were tested before and after training. **Results** Standing vertical jump-and-reach performance was significantly higher in the 80% 1RM group than in the 70% 1RM group and the 90% 1RM group ($P < 0.05$). Standing long-jump performance in the 80% 1RM group was significantly higher than that in the 90% 1RM group ($P < 0.05$). The peak torque of knee extension at 60°/s was significantly higher in the 90% 1RM group than in the 70% 1RM group and the 80% 1RM group ($P < 0.05$); the peak torque of knee flexion at 180°/s in the 80% 1RM group was significantly higher than that in the 70% 1RM group and the 90% 1RM group ($P < 0.05$). The lactic acid (LA) clearance rate and testosterone (T) level in the 80% 1RM group were significantly higher than those in the 70% 1RM group and the 90% 1RM group ($P < 0.05$); creatine kinase (CK) and cortisol (Cor) levels in the 90% 1RM group were significantly higher than those in the other two groups ($P < 0.05$). **Conclusion** Eight weeks of squat training with different loads shows load specificity in non-professional male college basketball players. The 80% 1RM load has the best overall effect in improving lower-limb explosive power and rapid contraction capacity and in regulating metabolic and anabolic hormones; the 90% 1RM load is more conducive to improving the maximal strength of the knee extensors, but is accompanied by stronger muscle damage and stress responses; the effect of the 70% 1RM group is relatively weak.

Key words: squat; load; college student; non-professional male basketball player; lower-limb explosive power; isokinetic muscle strength; biochemical parameter

As a high-intensity intermittent confrontation event, basketball performance is highly dependent on athletes' lower-limb explosive power[1-2]. The musculoskeletal system of college athletes is not yet fully mature; excessive loads may increase the risk of sports injury, whereas insufficient loads make it difficult to achieve effective training stimulation. Therefore, the scientific optimization of lower-limb explosive-power training programs is an urgent practical need[3]. Existing studies indicate that the core of lower-limb explosive-power training lies in optimizing the efficiency of force output, and deep squatting, as a basic resistance-training method, is widely applied in basketball physical training because its movement pattern is highly consistent with basketball-specific movements such as takeoff and landing[4]. However, current research on squat-training methods has obvious limitations: most studies focus on a single load or short-term effects, lack systematic comparisons among squat training with different loads, and provide insufficient exploration of the mechanisms of action[5-6]. In addition, traditional training often neglects assessments of isokinetic muscle strength and monitoring of physiological parameters, making training effects difficult to quantify. This knowledge gap not only restricts the scientific development of training, but may also increase the risk of sports injury owing to inappropriate load selection.

In recent years, some progress has been made in research on lower-limb explosive power through squat training, but key controversies and gaps remain. On the one hand, there are divergent views on the selection of load intensity[6-7]. On the other hand, existing studies have paid more attention to apparent indicators, such as jump height or sprint time, while neglecting in-depth discussion of metabolic and physiological-biochemical aspects. Therefore, the effects and mechanisms by which squatting with different loads improves explosive power remain unclear. This study takes non-professional male college basketball players as the research subjects and systematically compares the effects of squat training with different loads–70% of one-repetition maximum (1 repetition maximum, 1RM), 80% 1RM, and 90% 1RM—on lower-limb explosive power, knee-joint isokinetic muscle strength, and serum biochemical parameters, aiming to provide non-professional male college basketball players with a⋯

population, thereby providing scientific evidence for the formulation of precise lower-limb strength training programs and reducing the risk of excessive training.

1 Subjects and Methods

1.1 Study Participants

This study selected 36 non-professional male college basketball players as the research participants. Inclusion criteria: (1) age > 18 years, training experience > 1 year; (2) no history of lower-limb injury in the past 6 months; (3) able to proficiently perform weight-bearing deep squats, with a 1RM squat performance ≥ 1.5 times body mass; (4) signed informed consent. Exclusion criteria: (1) presence of cardiovascular disease or metabolic syndrome; (2) currently receiving medication that affects muscle function; (3) participation in other strength-training programs during the experiment. The 36 participants were randomly divided into 70% 1RM, 80% 1RM, and 90% 1RM groups, with 12 participants in each group. This study was approved by the Ethics Review Committee of Nanjing Tech University (No. NTJTECH-1-26).

1.2 Pre-Experimental Preparation

First, the direct testing method for squat 1RM of the National Strength and Conditioning Association (NSCA) was used to measure each participant's loaded squat 1RM. The measurement method was as follows: participants first warmed up, using a weight with which they could easily complete 5-10 squats. After resting for 1 min, the load was increased by 10%-20% on the basis of the original weight, and the weight was estimated to allow 3-5 repetitions; after resting for 2 min, the load was again increased by 10%-20% and adjusted to a weight close to the maximum that could be repeated 2-3 times, followed by another 2-4 min rest; subsequently, on the basis of the previous weight, the load was increased by another 10%-20% to attempt lifting the 1RM load. If successful, after resting for 2-4 min, the load was repeatedly increased for another attempt; if unsuccessful, after resting for 2-4 min, the load was reduced by 5%-10% and the attempt was repeated. Adjustments were made in this manner until the participant could complete one maximal squat with standard technique, and the 1RM value was determined within 5 attempts.

Before the formal experiment, the baseline lower-limb explosive power indicators, isokinetic muscle strength test indicators, and sports biochemical parameters of all participants were tested according to the methods described below.

1.3 Experimental Protocol

Warm-up: before each training session, a 15-min progressive warm-up was performed. First, participants jogged slowly for 3 laps. Next, they performed 4 × 8 unarmed calisthenics movements (neck movements, chest-expansion movements, arm-swinging movements, abdominal and back movements, waist circles, and knee circles). Finally, they performed a specific warm-up, including 3 sets × 10 repetitions of unweighted squats and 2 sets × 5 repetitions of squats with 20 kg load. After the final set, they rested for 5 min before entering formal training.

Formal training: participants in the 70% 1RM, 80% 1RM, and 90% 1RM groups performed back-squat strength training using constant loads of 70% 1RM, 80% 1RM, and 90% 1RM, respectively. Each group performed 6 repetitions per set, 4 sets each session, with 3 min of rest between sets. Training was conducted twice per week for a total of 8 weeks.

1.4 Test Indicators

1.4.1 Lower-Limb Explosive Power Indicators

Lower-limb explosive power indicators were tested before training and 48 h after the end of training, including countermovement jump height, single-leg countermovement jump height with approach, standing long jump, and three-quarter-court basketball sprint.

Countermovement jump height: the height of the movable colored plastic slider in the device was adjusted so that it was within the range reachable by the athlete when standing. First, the reach height of the fingertips of the participant' s dominant-side hand in an upright standing position was measured. After recording the standing reach height, the testing height was adjusted to a sufficiently challenging position. The athlete, without extra preparatory movements, rapidly flexed the knees and hips, swung both arms synchronously downward and backward, then immediately swung the arms upward and jumped forcefully. At the highest point, the fingertips of the dominant-side hand were used to touch the highest possible point, and no step jump was allowed. The difference between the jump touch height and the standing reach height was recorded. Each participant was tested 3 times, and the best result was recorded.

Single-leg countermovement jump height with approach: according to the testing protocol for the countermovement jump height, the participant' s standing reach height was first measured and recorded. The participant then performed an approach and single-leg takeoff, using the fingertips of the dominant-side hand to touch as high as possible. The difference between the jump touch height and the standing reach height was recorded as the measurement result. Each participant was tested 3 times, and the best result was taken. The unit was centimeters, recorded to the nearest integer. There were no special requirements for the left or right side of the touching hand and single-leg takeoff.

Standing long jump: the participant stood behind the takeoff line, with the feet separated left and right at a width equal to or slightly wider than shoulder width, and completed the jump according to the standard standing long jump action. The test score was the distance from the takeoff line or its extension to the nearest landing point (the rear heel). Each participant was tested 3 times, and the best result was taken. If the participant stepped over the takeoff line during the test, or if any body part other than the feet touched the ground upon landing, the test had to be repeated once.

Three-quarter-court basketball sprint: the participant prepared in a standing starting posture outside the basketball end line. After the starter issued the command, the timers began timing according to the signal. The participant sprinted at maximum speed toward the opposite free-throw line. When the participant crossed the free-throw line, the timers stopped the stopwatch and recorded the three-quarter-court sprint performance. The test result was the median value recorded by 3 timers. Each participant was tested once.

1.4.2 Isokinetic Muscle Strength Test

Before training and 48 h after the end of training, a BiodexS4 isokinetic muscle strength evaluation system was used to conduct isokinetic muscle strength testing for all participants. During the test, participants were required to participate with maximal effort to ensure the accuracy of maximal muscle strength data, and during the process they repeatedly entered a high-intensity anaerobic metabolic state.

The subjects performed the dominant-leg flexion and extension test on the testing device: both hands tightly gripped the handles, the dominant leg was fixed with straps, the lower back was pressed tightly against the backboard, and knee flexion and extension movements were completed. First, 5 leg flexion–extension tests were completed at an angular velocity of 60°/s; after a 2 min rest, 16 leg flexion–extension tests were performed at an angular velocity of 180°/s. All test modes were isokinetic concentric.

1.4.3 Serum biochemical parameter testing

A total of 4 blood samples were collected in this study. The specific time points were as follows: fasting state before training; immediately after the last training session; 10 min after the last training session; fasting state 48 h after the end of training. For each sampling, 3 mL of cubital venous blood was collected. After collection, it was immediately placed in a 4 ℃ environment and centrifuged at 3 000 r/min for 15 min to separate serum, which was used for subsequent biochemical indicator testing.

Lactic acid (LA) clearance rate: blood was collected immediately after the last training session and 10 min after training. The blood lactate concentration was measured using a Lactate scout4 lactate analyzer (EKF, Germany), and the LA clearance rate was calculated.

Creatine kinase (CK): before training and 48 h after the end of training, 3 mL of fasting venous blood was collected and centrifuged at 4 ℃ and 3 000 r/min for 15 min to separate serum. The activity of CK in serum was measured using a ZY-680 fully automatic biochemical analyzer (Shanghai Kehua Bio-engineering Co., Ltd.).

Cortisol (Cor): before training and 48 h after the end of training, the serum cortisol concentration was measured by enzyme-linked immunosorbent assay (ELISA) (item no. AB7449, Shanghai Enzyme-linked Biotechnology Co., Ltd.).

Testosterone (T): before training and 48 h after the end of training, the serum testosterone level was measured by ELISA (item no. SHC-0779H1, Nanjing Saihongrui Biotechnology Co., Ltd.).

1.5 Statistical analysis

Data are expressed as "mean ± standard deviation."SPSS 22.0 software was used to analyze the data. Normality tests and homogeneity-of-variance tests were first performed. One-way analysis of variance was used to compare differences among groups, and LSD tests were used for post hoc pairwise comparisons. $P < 0.05$ was considered statistically significant.

2 Results

2.1 Comparison of general information among the three groups of subjects

The subjects were 20–23 years old, with an average age of (21.58 ± 1.16) years; their height was 175-185 cm, with an average of (179.39 ± 3.16) cm; body mass was 72–80 kg, with an average of (76.06 ± 2.54) kg; body mass index (BMI) was 21.04-26.12 kg/m^2, with an average of (23.66 ± 1.15) kg/m^2; and training experience was 1-4 a, with an average of (2.78 ± 1.17) a. There were no statistically significant differences in general information among the three groups of subjects ($P > 0.05$), as shown in Table 1.

Table 1 Comparison of general information of the three groups of subjects

Tab. 1 Comparison of general information of the three groups of subjects

Parameter	70%1RM group	80%1RM group	90%1RM group	F	P
Age/years	21.67±1.07	21.83±1.11	21.25±1.29	0.802	0.457
Height/cm	179.25 ± 3.17	179.92 ± 3.06	179.00 ± 3.44	0.259	0.773
Body mass/kg	75.75±2.01	76.83±2.76	75.58±2.81	0.849	0.437

Parameter	70%1RM group	80%1RM group	90%1RM group	F	P
BMI/(kg· m^{-2})	23.59±0.97	23.76±1.33	23.61±1.23	0.073	0.930
Training experience/a	2.83 ± 1.40	2.75 ± 1.14	2.75 ± 1.06	0.019	0.981

2.2 Effects of deep squats with different loads on lower-limb explosive power indicators in non-professional male college basketball players

Before training, there were no statistically significant differences among the three groups of subjects in standing vertical jump height, run-up single-leg touch height, standing long jump, and three-quarters-court basketball sprint performance ($P > 0.05$). After training, the above lower-limb explosive power indicators of the three groups of subjects all improved significantly ($P < 0.05$); there were no statistically significant differences among the three groups of subjects in run-up single-leg touch height and three-quarters-court basketball sprint performance ($P > 0.05$); the standing vertical jump touch height of the 80%1RM group was significantly higher than that of the 70%1RM group and the 90%1RM group ($P < 0.05$); the standing long jump performance of the 80%1RM group was significantly higher than that of the 90%1RM group ($P < 0.05$). The lower-limb explosive power indicators of the three groups of subjects are shown in Table 2.

Table 2 Comparison of lower limb explosive power indicators among the three groups of subjects

Tab. 2 Comparison of lower limb explosive power indicators among the three groups of subjects

Explosive power parameter	Time	70%1RM group	80%1RM group	90%1RM group	F	P
Standing vertical jump touch height/cm	Pre-test	67.42 ± 1.83	68.67 ± 1.72	68.17 ± 2.04	1.360	0.271

Explosive power parameter	Time	70%1RM group	80%1RM group	90%1RM group	*F*	*P*
Standing vertical jump touch height/cm	Post-test	72.75 ± 2.05	75.67 ± 2.27*	71.50 ± 2.75#	9.738	<0.001

Table 2 (continued)

Explosive power parameter	Time	70%1RM group	80%1RM group	90%1RM group	*F*	*P*
Single-leg approach jump height/cm	Pre-test	74.42 ± 2.43	75.00 ± 2.17	74.83 ± 1.95	0.225	0.799
Single-leg approach jump height/cm	Post-test	77.92 ± 2.54	79.50 ± 2.02	77.50 ± 1.88	2.846	0.072
Standing long jump/cm	Pre-test	271.25 ± 3.62	271.33 ± 2.87	269.92 ± 3.12	0.732	0.489
Standing long jump/cm	Post-test	277.50 ± 3.37	279.92 ± 2.71	275.33 ± 3.06#	6.746	0.003
Three-quarter-court basketball sprint/s	Pre-test	3.85 ± 0.09	3.78 ± 0.08	3.78 ± 0.10	1.890	0.167

Explosive power parameter	Time	70%1RM group	80%1RM group	90%1RM group	*F*	*P*
Three-quarter-court basketball sprint/s	Post-test	3.74 ± 0.09	3.65 ± 0.08	3.68 ± 0.10	2.603	0.089

Note: Compared with the 70%1RM group, ^^ P*<0.05; compared with the 80%1RM group,* # P*<0.05.

2.3 Effect of Different Load Depth Jumps on Knee-Joint Isokinetic Muscle Strength in Non-Professional Male College Basketball Players

Before training, there were no statistically significant differences among the three groups of subjects in the peak torque values of knee extension and knee flexion at 60°/s and 180°/s (P>0.05). After training, the knee-joint isokinetic muscle strength parameters of the three groups of subjects all increased significantly (P<0.05); among the three groups, there was no statistically significant difference in the peak torque of knee flexion at 60°/s and knee extension at 180°/s (P>0.05); the peak torque of knee extension at 60°/s in the 90%1RM group was significantly higher than that in the 70%1RM group and the 80%1RM group (P<0.05); the peak torque of knee flexion at 180°/s in the 80%1RM group was significantly higher than that in the 70%1RM group and the 90%1RM group (P<0.05). The knee-joint isokinetic muscle strength parameters of the three groups of subjects are shown in Table 3.

Table 3 Comparison of isokinetic muscle strength parameters of the knee joint among the three groups of subjects

Isokinetic muscle strength parameter	Time	70%1RM group	80%1RM group	90%1RM group	F	P
Knee extension 60°/s peak torque/(N·m^{-1})	Pre-test	218.55 ± 11.89	213.89 ± 11.07	222.33 ± 16.99	1.167	0.324
Knee extension 60°/s peak torque/(N·m^{-1})	Post-test	238.95 ± 11.95	238.45 ± 10.38	252.00 ± 17.08^*#^	3.916	0.030
Knee flexion 60°/s peak torque/(N·m^{-1})	Pre-test	108.75 ± 7.67	101.98 ± 8.71	102.58 ± 6.85	2.780	0.077
Knee flexion 60°/s peak torque/(N·m^{-1})	Post-test	127.67 ± 7.41	126.33 ± 9.09	132.64 ± 7.50	2.055	0.144
Knee extension 180°/s peak torque/(N·m^{-1})	Pre-test	152.77 ± 13.22	157.54 ± 8.70	154.15 ± 10.56	0.597	0.556
Knee extension 180°/s peak torque/(N·m^{-1})	Post-test	165.53 ± 13.44	173.41 ± 9.42	164.19 ± 10.84	2.310	0.115

Isokinetic muscle strength parameter	Time	70%1RM group	80%1RM group	90%1RM group	*F*	*P*
Knee flexion 180°/s peak torque/(N· m^{-1})	Pre-test	86.63 ± 3.16	88.86 ± 4.03	89.16 ± 3.63	1.750	0.190
Knee flexion 180°/s peak torque/(N· m^{-1})	Post-test	99.69 ± 3.47	104.61 ± 4.16^*^	99.48 ± 3.70$^{\#}$	7.051	0.003

Note: Compared with the 70%1RM group, ^^ P*<0.05; compared with the 80%1RM group,* $^{\#}$ P*<0.05.

2.4 Effect of Different Load Depth Jumps on Serum Biochemical Parameters in Non-Professional Male College Basketball Players

Before training, there were no statistically significant differences among the three groups of subjects in LA clearance rate, CK, Cor, and T levels (*P*>0.05). After training, the serum biochemical parameters of the three groups of subjects all increased significantly (*P*<0.05); the LA clearance rate and T level in the 80%1RM group were significantly higher than those in the 70%1RM group and the 80%1RM group (*P*<0.05); CK and Cor in the 90%1RM group were significantly higher than those in the 70%1RM group and the 80%1RM group (*P*<0.05). The serum biochemical parameters of the three groups of subjects are shown in Table 4.

Table 4 Comparison of serum biochemical parameters of the three groups of subjects

Serum biochemical parameter	Time	70%1RM group	80%1RM group	90%1RM group	*F*	*P*
LA clearance rate/%	Pre-test	16.98 ± 0.96	17.36 ± 0.96	17.47 ± 1.52	0.580	0.565
LA clearance rate/%	Post-test	22.00 ± 1.03	24.51 ± 1.32^*^	20.61 ± 1.45^*#^	28.578	<0.001
CK/(U·L^{-1})	Pre-test	178.45 ± 8.48	175.45 ± 7.71	179.07 ± 14.89	0.383	0.685
CK/(U·L^{-1})	Post-test	219.31 ± 9.20	234.88 ± 7.78^*^	258.34 ± 16.08^*#^	34.412	<0.001
Cor/(nmol·L^{-1})	Pre-test	446.37 ± 19.88	449.12 ± 20.84	448.75 ± 23.14	0.059	0.943
Cor/(nmol·L^{-1})	Post-test	487.29 ± 21.19	512.97 ± 17.79^*^	526.64 ± 23.73^*#^	10.813	<0.001
T/(ng·dL^{-1})	Pre-test	640.90 ± 37.27	659.42 ± 41.72	651.48 ± 29.11	0.782	0.466
T/(ng·dL^{-1})	Post-test	682.72 ± 37.69	715.48 ± 40.28^*^	680.35 ± 30.80^*#^	3.477	0.043

Note: Compared with the 70%1RM group, ^^ P*<0.05; compared with the 80%1RM group,* # P*<0.05.

3 Discussion

Post-activation potentiation is a physiological phenomenon in which subsequent exercise performance is temporarily enhanced after the body has undergone short-duration, high-intensity exercise. As a common strength-training movement, the squat can induce this effect at appropriate intensities and thereby help improve subsequent strength performance; its loading intensity (e.g., different RM values) influences the effect. In squat training, according to differences in load intensity, loads may be classified as moderate intensity (60%–84% 1RM) and high intensity (85% 1RM and above). At present, scholars in various countries have not yet reached a unified conclusion regarding the specific load selection for post-activation potentiation. The post-activation potentiation effects produced after interventions with different loads differ[^8]. For example, Tillin et al.[^9] believed that after intervention with high-intensity loads, post-activation potentiation is more pronounced. Wilson et al.[^10], however, found that the best exercise performance occurs after moderate-intensity intervention. Based on previous studies, the present study set three loads—70% 1RM, 80% 1RM, and 90% 1RM—in order to further reveal the mechanism by which squats with different loads affect lower-limb explosive power in non-professional male university basketball players.

The results of this study showed that, after 8 weeks of squat training with different loads, the standing vertical jump height, standing long jump, and other explosive-power indicators of the three groups of subjects all improved significantly. However, the 80% 1RM group performed better in the standing vertical jump height and standing long jump, whereas there were no intergroup differences in the assisted-run single-leg jump height and the three-quarter-court basketball sprint results. This phenomenon is closely related to the force–velocity relationship and the specific demands of the sport. The essence of explosive power is the power output by muscles within a short time (power = force × velocity), and its improvement depends on the coordinated development of maximal strength and contraction velocity. A 70% 1RM load is a moderate-to-low load. Although it can increase neural conduction velocity through high-frequency contractions, because the stimulus intensity is insufficient, it is difficult to effectively activate the proliferation and hypertrophy of type II muscle fibers (fast-twitch fibers), leading to limited growth in maximal strength and thereby restricting the upper limit of power output[^11]. A 90% 1RM load is a high load; although it can significantly increase maximal strength, it must be completed at a relatively slow movement velocity, and long-term training may reduce muscle contraction velocity, which is instead unfavorable for improving explosive power. An 80% 1RM load can both provide sufficient mechanical tension to stimulate muscle-fiber hypertrophy (especially type II fibers) and maintain a relatively high movement velocity so as to preserve neuromuscular synchronous activation capacity, ultimately maximizing power output[^11]. It is worth noting that there were no differences among groups in assisted-run single-leg jump height and sprint performance. This may be related to the complexity of the movement patterns. The assisted-run jump height involves coordinated force production by lower-limb push-off and upper-limb arm swing, while sprinting depends on dynamic regulation of stride frequency and stride length; both require coordinated cooperation of multiple joints throughout the whole body. By contrast, the squat, as a single-joint-dominant closed-chain training movement, has limited influence on the integration capacity of the central nervous system in complex movement patterns. In addition, the study by Li Hongbiao[^11] likewise supports that 80% 1RM has the best effect on improving explosive power in jump athletes: the standing long jump and 30 m running performance in the 80% group were significantly better than those in other load groups, corroborating the findings of the present study. In other studies, Zheng Caiyun[^12] selected 10 male sprint athletes and carried out squat interventions with loads of 75% 1RM, 80% 1RM, and 85% 1RM; the results showed that the post-activation potentiation effect induced by 85% 1RM was more prominent. Yang Lin[^13] used loads of 30% 1RM, 50% 1RM, 60% 1RM, 70% 1RM, and 80% 1RM for squat intervention, and the experiment showed that after intervention with 70% RM and 80% RM squat loads, the post-activation potentiation effect was best. Zhou Yongmei et al.[^14], in a study on post-activation potentiation, found that 5 sets of 95% 1RM squat stimulation could increase the rapid strength of the lower limbs of taekwondo athletes by 5%-30% and could effectively enhance explosive hip-joint power. Combining the results of the present study, the author believes that squat load does not have a linear relationship with lower-limb explosiveness; in squat training for non-professional male university basketball players, an appropriate load should be selected.

The results of the knee-joint isokinetic muscle-strength test revealed the differential effects of squats with different loads on the strength of the flexor and extensor muscle groups. The 90% 1RM group showed better knee-extension torque peak values at 60°/s, whereas the 80% 1RM group showed more prominent knee-flexion torque peak values at 180°/s. This is closely related to the muscle-force generation mechanisms at different angular velocities. In isokinetic testing, 60°/s is a slow angular velocity and mainly reflects maximal voluntary muscle contraction force; its improvement depends on increases in muscle cross-sectional area and the number of sarcomeres[^15]. High-load training at 90% 1RM, through mechanical-tension stimulation, can significantly activate satellite-cell proliferation and promote myofibrillar protein synthesis. It has a particularly significant hypertrophic effect on type I muscle fibers (slow-twitch fibers) of the quadriceps femoris (knee extensors), and therefore is more conducive to increasing muscle strength[^16]. By contrast, 180°/s is a fast angular velocity and reflects rapid muscle contraction ability, the core of which is neuromuscular activation efficiency. Training at 80% 1RM, through the combination of a moderate load and relatively high movement velocity, may be more conducive to enhancing the excitability of α motor neurons and improving the sensitivity of muscle spindles to stretch stimulation, thereby helping to activate type IIa muscle fibers (which combine strength and speed characteristics) in the hamstring muscles (knee flexors). In addition, there were no differences between groups in torque peak values for knee flexion at 60°/s and knee extension at 180°/s. This may be because the degree of match between the load demands and the training stimulus in these two modes was relatively low: slow-velocity power generation in knee flexion appears less often in basketball (for example, landing buffering is mostly a rapid movement), while for fast-velocity power generation in knee extension, the high load of 90% 1RM limited movement velocity and the low load of 70% 1RM was insufficient to stimulate strength growth, ultimately leading to nonsignificant intergroup effects.

The results of serum biochemical indicators showed that the 80% 1RM group had a higher LA clearance rate and T level, while the 90% 1RM group had higher CK and Cor levels. This difference reflects distinctions in the metabolic stress and hormone-regulation mechanisms induced by training with different loads. LA clearance rate is an important indicator of aerobic metabolic capacity, and its improvement depends on increases in mitochondrial number and glycogen availability.

Lactate dehydrogenase activity is enhanced[17]. During 80% 1RM training, exercise intensity lies in the aerobic–anaerobic mixed metabolic zone (heart rate approximately 140–160 beats/min), which can effectively stimulate myocardial contractility and increase capillary density, promoting the transport of LA through the blood circulation to tissues such as the liver and myocardium for oxidative energy supply. Therefore, its clearance rate is significantly higher than that of 70% 1RM (excessively high aerobic contribution and insufficient stimulation) and 90% 1RM (excessively high anaerobic contribution, with LA accumulation exceeding clearance capacity). Testosterone, as a major anabolic metabolic hormone, when elevated, can accelerate muscle protein synthesis and satellite-cell differentiation[18]. The metabolic stress produced by 80% 1RM training is moderate: it avoids the "insufficient stimulation" of 70% 1RM (less testosterone secretion) and does not trigger the excessive stress response of 90% 1RM (elevated Cor suppressing the action of testosterone), and therefore shows the highest level. In the 90% 1RM group, CK and Cor increased significantly, which is related to muscle microinjury and stress response. During high-load training, excessive mechanical traction on the sarcolemma increases permeability, causing a large amount of intracellular CK to be released into the blood[19]. Meanwhile, the body secretes Cor through the hypothalamic–pituitary–adrenal axis in response to high-intensity stress. Although Cor can promote glycogenolysis for energy supply, excessive secretion suppresses immune function and testosterone synthesis, which is unfavorable for post-training recovery[18]. This suggests that 90% 1RM training may carry a risk of overtraining, whereas 80% 1RM can achieve a balance between effective stimulation and sufficient recovery.

4 Conclusion

The effects of 8 weeks of deep-squat training with different loads on non-specialist male college basketball players exhibit load specificity. The 80% 1RM group showed the best overall effects in regulating lower-limb explosive power, rapid contraction ability, and metabolic and anabolic hormones; the 90% 1RM group was more beneficial for improving maximal knee-extensor strength but was accompanied by stronger muscle damage and stress responses; and the 70% 1RM group showed weaker effects. This study reveals the specific effects of deep squats with different loads on lower-limb explosive power, muscle strength, and biochemical indicators in non-specialist male college basketball players. The findings can directly provide a scientific basis for formulating precise lower-limb strength-training programs for this population, avoiding injuries caused by high loads and inefficiency caused by low loads, while helping to improve basketball-specific physical fitness and fill a gap in load-specific research in related fields.

References:

[1] Zhong Yinfei, Wen Xinfei, Lu Di. Research on the influence of basketball shoes with different upper heights on ankle stability and dynamics[J]. Chinese

Journal of Applied Mechanics, 2024, 41(6): 1418-1427.
Zhong Yinfei, Wen Xinfei, Lu Di. Research on the influence of basketball shoes with different upper heights on ankle stability and dynamics[J]. Chinese Journal of Applied Mechanics, 2024, 41(6): 1418-1427 (in Chinese).

[2] Liu Jun, Cheng Liping, Xu Jianhua. Inspirations from the research results of basketball game load characteristics to stamina training[J]. Journal of Physical Education, 2012, 19(5): 108-112.
Liu Jun, Cheng Liping, Xu Jianhua. Inspirations from the research results of basketball game load characteristics to stamina training[J]. Journal of Physical Education, 2012, 19(5): 108-112 (in Chinese).

[3] Zhu Xueqiang, Liu Fenghu. Effects of plyometric training on the lower limb explosive power of college male basketball players[J]. Chinese Journal of Applied Mechanics, 2025, 42(3): 712-722.
Zhu Xueqiang, Liu Fenghu. Effects of plyometric training on the lower limb explosive power of college male basketball players[J]. Chinese Journal of Applied Mechanics, 2025, 42(3): 712-722 (in Chinese).

[4] Wang Zhihui. Effects of velocity-based strength training during deep squats on lower-limb explosive power and other motor abilities of college basketball players[D]. Wuhan: Wuhan Institute of Physical Education, 2020.

[5] Jiang D T, Xu G. Effects of chains squat training with different chain load ratio on the explosive strength of young basketball players' lower limbs[J]. Frontiers in Physiology, 2022, 13: 979367.

[6] Zhang Shuai, Zhao Liang, Wan Fatong, et al. Effects of different velocity loss thresholds (10% vs 20%) on lower extremity explosive force of college athletes in velocity-based strength training[J]. China Sport Science and Technology, 2023, 59(7): 39-46.
Zhang Shuai, Zhao Liang, Wan Fatong, et al. Effects of different velocity loss thresholds (10% vs 20%) on lower extremity explosive force of college athletes in velocity-based strength training[J]. China Sport Science and Technology, 2023, 59(7): 39-46 (in Chinese).

[7] Zhang Ning. Study on the effects of super-heavy-load deep-squat training on lower-limb explosive power in male high-school basketball players[D]. Linfen: Shanxi Normal University, 2019.

[8] Liu Bingbing. Study on the effects of activation post-enhancement induced by deep squats with different loads on lower-limb explosive power in male basketball-specialty students[D]. Chengdu: Sichuan Normal University, 2023.

[9] Tillin N A, Bishop D. Factors modulating post-activation potentiation and its effect on performance of subsequent explosive activities[J]. Sports Medicine, 2009, 39(2): 147-166.

[10] Wilson J M, Duncan N M, Marin P J, et al. Meta-analysis of postactivation potentiation and power: effects of conditioning activity, volume, gender, rest

periods, and training status[J]. Journal of Strength and Conditioning Research, 2013, 27(3): 854-859.

[11] Li Honghu. Study on the effects of post-activation potentiation on lower-limb explosive power in 18–19-year-old male long-jump athletes[D]. Shijiazhuang: Hebei Normal University, 2023.

[12] Zheng Caiyun. Study on the effects of post-activation potentiation on lower-limb explosive power in male sprinters[D]. Wuhan: Wuhan Institute of Physical Education, 2020.

[13] Yang Lin. Effects of half squats with different loads on post-activation potentiation in standing long jump among physical-education college-entrance examinees[D]. Beijing: Beijing Sport University, 2020.

[14] Zhou Yongmei, Zhang Hui. Post-activation potentiation on rapid lower-limb strength in taekwondo athletes WeChat public account: Journal of Applied Mechanics

···effect [J]. Shandong Sports Science & Technology, 2021, 43(5): 37–43.

Zhou Yongmei, Zhang Hui. Effect of post activation potentiation on the fast strength of lower limbs of taekwondo athletes [J]. Shandong Sports Science & Technology, 2021, 43(5): 37–43 (in Chinese).

[15] Liao Guilin. Experimental study on the effects of cluster training on the maximal strength and explosive power of the lower limbs of basketball-specialty students [D]. Nanjing: Nanjing Sport Institute, 2022.

[16] Morton R W, Sonne M W, Farias Z A, et al. Muscle fibre activation is unaffected by load and repetition duration when resistance exercise is performed to task failure [J]. The Journal of Physiology, 2019, 597(17): 4601–4613.

[17] Burgomaster K A, Heigenhauser G J F, Gibala M J. Effect of short-term sprint interval training on human skeletal muscle carbohydrate metabolism during exercise and time-trial performance [J]. Journal of Applied Physiology, 2006, 100(6): 2041–2047.

[18] Kraemer W J, Ratamess N A, Hymer W C, et al. Growth hormone(s), testosterone, insulin-like growth factors, and cortisol: roles and integration for cellular development and growth with exercise [J]. Frontiers in Endocrinology, 2020, 11: 33.

[19] Suraha O, Malczewska-Lenczowska J, Sitkowski D, et al. Effect of training load on sleep parameters and biochemical fatigue markers in elite swimmers [J]. Biology of Sport, 2023, 40(4): 1229–1237.

(Editor: Zhang Lu)

Note: Figure translations are in progress. See original paper for figures.