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Research Article

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**Effects of 12 Weeks of French Contrast Training on Lower-Limb Explosive
Performance in Male Collegiate Basketball Players**

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Abstract

Objective: This study aimed to investigate the effects of 12 weeks of French Contrast Training (FCT) on lower-limb explosive performance in male college basketball players compared with resistance training (RT).

Methods: Forty male college basketball players were randomly assigned to either the FCT group (n = 20) or the RT group (n = 20). Both groups completed a 12-week training program, with two sessions per week and at least 48 hours of recovery between sessions. The FCT protocol consisted of four sequential exercises: 85% 1RM squat, 30-cm hurdle jump, 25% 1RM squat jump, and band-assisted jump. The RT group performed a traditional resistance training program. Outcomes were assessed before and after the intervention, including countermovement jump (CMJ), drop jump (DJ), ground contact time (GCT), reactive strength index (RSI), 10-m sprint time, and isometric mid-thigh pull (IMTP) peak force output. We used two-way repeated measures analysis of variance (ANOVA) (time × group) with Bonferroni post hoc tests, and effect sizes were reported as partial eta squared (η_p^2). $p < 0.05$ was statistically significant.

Results: FCT yielded greater improvements than RT in CMJ ($p = 0.044$, $\eta_p^2 = 0.102$), DJ ($p = 0.035$, $\eta_p^2 = 0.112$), GCT ($p = 0.007$, $\eta_p^2 = 0.177$), RSI ($p < 0.001$, $\eta_p^2 = 0.251$), 10-m sprint time ($p = 0.013$, $\eta_p^2 = 0.152$), and peak force output ($p = 0.034$, $\eta_p^2 = 0.113$).

Conclusions: This study suggests that French Contrast Training is an effective strategy for improving lower-limb explosive performance in male college basketball players.

Keywords: French Contrast Training, Resistance Training, Explosive Performance, Acceleration, Ground Contact Time, Reactive Strength Index

Clinical trial number: not applicable.

1 Introduction

Basketball is a high-intensity, intermittent team sport characterized by repeated offensive and defensive transitions, during which players frequently perform explosive actions such as short-distance accelerations, vertical jumps, and defensive slides within limited recovery periods (1, 2). These movements require players to produce force rapidly under varying conditions, placing substantial demands on lower-limb neuromuscular function (3, 4). Therefore, lower-limb explosive power, acceleration ability, and maximal strength are important components of physical fitness for basketball players (5). Resistance training (RT) is widely used to enhance lower-limb strength and power in basketball players (6, 7). For example, previous studies showed that RT can effectively enhance maximal strength and vertical jump performance in basketball players (8, 9). However, RT primarily targets the high-force, low-velocity region of the force-velocity (F-V) curve, with relatively limited stimulation of high-velocity force production and stretch-shortening cycle (SSC) efficiency. This may limit the transfer of maximal strength gains to rapid force production and explosive performance (10-12). Therefore, stimulating the full F-V curve and enhancing SSC efficiency may be more effective at translating strength gains into explosive performance (13, 14).

French Contrast Training (FCT) may be an effective strategy to address these limitations because it combines different loading and velocity exercises within a single session, thereby stimulating the full F-V curve (11, 15). Specifically, FCT consists of four sequential phases: 1) heavy compound exercises (e.g., 80 to 90% 1RM back squat); 2) plyometric exercises (e.g., vertical jumps); 3) light-to-moderate load exercises (e.g., 25 to 45% 1RM barbell weighted jumps); and 4) assisted plyometric exercises (e.g., band-assisted jumps) (16, 17). These complementary phases are designed to enhance maximal and rapid force production, as well as SSC-related neuromuscular function (18, 19). Previous studies reported that FCT can improve lower-limb explosive performance. For example, Zhao et al. demonstrated that FCT significantly improved jump and sprint performance in healthy adults (17). Similarly, Chen et al. reported that an 8-week FCT program significantly enhanced lower-limb explosive performance in elite martial arts (20). The only basketball-related study by Cengizel et al. examined the acute warm-up effects of the FCT in 3 × 3 basketball players, rather than the chronic adaptations induced by long-term FCT (21). Although FCT has shown potential to enhance lower-limb explosive performance, its chronic effects in basketball players remain unclear.

This study aims to address this gap by evaluating the effects of 12 weeks of FCT on lower-limb explosive performance compared to RT in college basketball players. To assess these effects, we measured countermovement jump (CMJ), drop jump (DJ), 10-meter sprint time, and isometric mid-thigh pull test (IMTP). We hypothesized that FCT would produce significantly greater improvements in CMJ, DJ, sprint time, and IMTP.

2 Methods

Participants

Sample size estimation was performed a priori, based on a previous study by Rebelo et al. (22), which reported a between-group effect size of 0.81 for CMJ performance. Using G*Power with a one-way ANOVA model, an effect size of $f = 0.40$, $\alpha = 0.05$, and power = 0.95, the minimum required sample size was calculated to be 24 participants. To account for potential dropouts and improve statistical robustness, 40 basketball players were recruited and randomly assigned to either the FCT group ($n = 20$) or the RT group ($n = 20$). All participants regularly undertook basketball-specific technical training three times per week and had no lower-limb injuries in the three months prior to enrolment. The study was approved by the Ethics Committee of Chongqing University of Education (CQUE-LL20260331009), and all procedures were conducted in accordance with the Declaration of Helsinki. Before participation, all participants provided written informed consent.

Study Design

This study was designed as a twelve-week, single-blind randomized controlled trial, with outcome assessors blinded to group allocation. Participants were randomly assigned to either the FCT group or the RT group using a computer-generated randomization sequence (**Figure 1**). The intervention was implemented during the preparatory phase of the competitive season. Prior to baseline testing, all participants completed a familiarization session to standardize the training procedures and testing protocols. Both groups trained twice per week, with at least 48 hours of rest between sessions. All training sessions were supervised by

certified strength and conditioning coaches, who provided standardized instructions to ensure consistent implementation of the intervention. To minimize the potential influence of circadian variation, all testing sessions were conducted at the same time of day for each participant. Participants were also instructed to refrain from strenuous physical activity for 48 hours before each testing session and to avoid alcohol and caffeine consumption 24 hours before testing.

Training Protocol

Participants in the FCT group performed a structured, four-phase sequence. Each sequence comprises: 1) heavy compound exercise (85% 1RM squat); 2) plyometric exercise (30cm hurdle jumps); 3) light-to-moderate load exercise (25% 1RM squat jumps); 4) assisted plyometric exercise (band-assisted jumps), with a 20-second rest in each exercise. Participants in the RT group performed a traditional program: 1) back squat at 85% 1RM; 2) Romanian deadlift at 85% 1RM; 3) leg press at 85% 1RM; and 4) walking lunge at 30% 1RM. Both groups completed 4 sets of 8 repetitions for each exercise, with 3 minutes of rest between sets (**Figure 2**).

Outcomes Measurement

CMJ

Participants stood upright on a force platform system (Kistler, Winterthur, Switzerland; sampling frequency: 1000 Hz), with both hands placed on the iliac crests to minimize the contribution of arm swing. After an auditory signal, participants rapidly descended into a self-selected squat depth and immediately performed a maximal vertical jump (23). Each

participant completed three maximal attempts, with a 1-minute rest interval between attempts. The highest jump height (cm) was recorded for subsequent analysis.

DJ

Participants stood upright on a 30-cm box placed behind a force platform system (Kistler, Winterthur, Switzerland; sampling frequency: 1000 Hz), with both hands placed on the iliac crests to minimize arm-swing contributions. After a signal, participants stepped off the box, landed bilaterally on the contact platform, and immediately performed a maximal vertical jump while attempting to minimize ground contact time. Participants were instructed not to jump upward or forward from the box before landing (24). Each participant completed three maximal attempts, with a 1-minute rest interval between attempts. The highest reactive strength index (RSI), jump height (cm) and ground contact time (ms) were recorded.

10-meter Sprint

Participants completed a standardized warm-up and then adopted a split-stance start position 0.5 m behind the first timing gate (Brower Timing Systems, Draper, UT, USA). After an auditory cue, participants sprinted maximally through 15 m to prevent early deceleration before the 10-m mark (25). Each participant completed three maximal trials, with 2–3 minutes of rest between trials. The fastest 10-m sprint time (s) was recorded for subsequent analysis.

IMTP

Participants stood on a force plate (Kistler, Winterthur, Switzerland; sampling frequency: 1000 Hz) with their feet shoulder-width apart, and the bar was individually positioned at mid-

thigh level. Knee and hip joint angles were standardized at approximately 130° and 145°, respectively, using a handheld goniometer. Participants were instructed to maintain a rigid body posture and full foot contact while pulling the bar upward as hard and as fast as possible for 3–5 seconds. Strong verbal encouragement was provided throughout each trial to promote maximal effort (26). Each participant completed three maximal attempts, with a 2-minute rest interval between attempts. The highest peak force value (N) obtained across the three attempts was recorded for subsequent analysis.

Statistical Analysis

We presented all data as mean $\pm$ standard deviation (SD) and assessed normality using the Shapiro–Wilk test. We conducted an analysis of outcomes using a two-way (time $\times$ group) repeated-measures ANOVA, with post hoc analyses using the Bonferroni test. We expressed effect size as partial eta-squared (η_p^2), where effect sizes were categorized as trivial ($\eta_p^2 < 0.01$), small ($0.01 \leq \eta_p^2 < 0.06$), moderate ($0.06 \leq \eta_p^2 < 0.14$), and large ($\eta_p^2 \geq 0.14$) effects. Descriptive statistics were provided only for the percentage change ($\Delta\%$). $p < 0.05$ was considered significant. Analyses used SPSS version 27.0 (IBM Statistics).

3 Results

Baseline performance outcomes did not differ significantly between groups ($p > 0.05$) (**Table 1**).

CMJ

A significant interaction effect between time and group was observed ($F = 4.335$, $p = 0.044$, $\eta_p^2 = 0.102$). The main effect of time showed a significant difference ($F = 44.751$, $p < 0.001$,

$\eta_p^2 = 0.541$). The main effect of the group showed a non-significant difference ($F = 0.124$, $p = 0.727$, $\eta_p^2 = 0.003$) (**Figure 3**).

The FCT group improved by 9.10% (from 43.51 to 47.36cm), compared to 4.64% (from 43.81 to 45.84cm) in the RT group.

DJ

A significant interaction effect between time and group was observed ($F = 4.798$, $p = 0.035$, $\eta_p^2 = 0.112$). The main effect of time showed a significant difference ($F = 36.207$, $p < 0.001$, $\eta_p^2 = 0.488$). The main effect of the group showed a non-significant difference ($F = 0.005$, $p = 0.941$, $\eta_p^2 = 0.001$) (**Figure 3**).

The FCT group improved by 8.82% (from 35.55 to 38.58cm), compared to 4.03% (from 36.46 to 37.88cm) in the RT group.

GCT

A significant interaction effect between time and group was observed ($F = 8.193$, $p = 0.007$, $\eta_p^2 = 0.177$). The main effect of time showed a significant difference ($F = 24.263$, $p < 0.001$, $\eta_p^2 = 0.390$). The main effect of the group showed a non-significant difference ($F = 0.039$, $p = 0.845$, $\eta_p^2 = 0.001$) (**Figure 3**).

The FCT group improved by 5.92% (from 221.20 to 208.57ms), compared to 4.64% (from 218.11 to 214.77ms) in the RT group.

RSI

A significant interaction effect between time and group was observed ($F = 12.735$, $p < 0.001$, $\eta_p^2 = 0.251$). The main effect of time showed a significant difference ($F = 70.493$, $p < 0.001$,

$\eta_p^2 = 0.650$). The main effect of the group showed a non-significant difference ($F = 0.014$, $p = 0.906$, $\eta_p^2 = 0.001$) (**Figure 3**).

The FCT group improved by 15.83% (from 1.63 to 1.89), compared to 5.90% (from 1.69 to 1.80) in the RT group.

10-m sprint time

A significant interaction effect between time and group was observed ($F = 6.838$, $p = 0.013$, $\eta_p^2 = 0.152$). The main effect of time showed a significant difference ($F = 50.543$, $p < 0.001$, $\eta_p^2 = 0.571$). The main effect of the group showed a non-significant difference ($F = 2.271$, $p = 0.140$, $\eta_p^2 = 0.056$) (**Figure 3**).

The FCT group improved by 3.69% (from 1.91 to 1.84s), compared to 1.72% (from 1.93 to 1.89s) in the RT group.

Peak Force Output

A significant interaction effect between time and group was observed ($F = 4.858$, $p = 0.034$, $\eta_p^2 = 0.113$). The main effect of time showed a significant difference ($F = 52.908$, $p < 0.001$, $\eta_p^2 = 0.582$). The main effect of the group showed a non-significant difference ($F = 0.257$, $p = 0.615$, $\eta_p^2 = 0.007$) (**Figure 3**).

The FCT group improved by 10.22% (from 2615.52 to 2873.69N), compared to 5.51% (from 2618.27 to 2756.36N) in the RT group.

4 Discussion

This is the first study to investigate the effects of FCT on lower-limb explosive performance in male college basketball players. The main findings showed that, compared to

RT, FCT produced greater improvements in CMJ, DJ, GCT, RSI, 10-m sprint time, and peak force output. These findings suggest that FCT may be a more effective training strategy than RT for enhancing lower-limb explosive performance in college basketball players.

The improvements in CMJ and DJ performance were consistent with previous findings. For example, Zhou et al. reported that an 8-week FCT program significantly improved CMJ in college badminton players (27). Similarly, Huang et al. found that 8 weeks of FCT led to greater improvements in DJ and RSI among elite adolescent badminton athletes (28). Notably, the present study further showed that FCT reduced GCT and increased RSI, suggesting an improved ability to rapidly convert eccentric braking into concentric propulsion during short ground-contact actions (29, 30). This adaptation is particularly important for basketball players because rebounding, blocking, and repeated take-off actions require efficient SSC function under short time conditions (29, 31). These adaptations may be explained by the specific sequence of FCT. The initial heavy compound exercise may increase neuromuscular excitation and enhance the readiness of high-threshold motor units (32, 33). When performed under this potentiated condition, the plyometric exercise repeatedly exposes athletes to rapid eccentric loading and short amortization phases, which may improve braking stiffness, elastic energy storage, and the transition from landing to take-off (32, 34). The following light-to-moderate load exercise may further reinforce powerful concentric propulsion in a movement pattern similar to vertical jumping(35), whereas the assisted plyometric exercise may provide an overspeed stimulus that promotes faster take-off velocity and shorter ground contact (36). Through repeated exposure to this sequence,

athletes may develop more efficient muscle-tendon interaction and better timing between eccentric braking and concentric propulsion.

The improvement of 10-m sprint time was also consistent with previous evidence. For example, Thomsen et al. reported that a 14-week FCT improved 10-m sprint time in male soccer players (37). 10-m sprint requires athletes to generate high levels of force rapidly within a very limited time, and this ability depends not only on maximal strength but also on the capacity to express force at high velocity (38). FCT may enhance this capacity by stimulating the full F-V curve. In the FCT sequence, heavy compound exercises may provide a high load stimulus, whereas plyometric, light-to-moderate load, and assisted plyometric exercises may progressively emphasize rapid force production and high-velocity movement (11, 15, 27). This combination may effectively enhance the transfer of lower-limb strength to early acceleration performance. However, because the present study did not directly assess horizontal ground reaction forces or sprint kinematics, this explanation should be interpreted as a potential mechanism.

The improvement in IMTP peak force suggests that FCT may also enhance maximal isometric force. Unlike CMJ, DJ, and 10-m sprint, IMTP is less dependent on movement velocity or SSC efficiency and more closely reflects the athlete's capacity to produce maximal force (39). The improvement may be partly attributed to repeated exposure to heavy compound exercise within each training sequence, which may increase neuromuscular drive and recruit high-threshold motor units (32, 33, 40). In addition, performing explosive

exercises after heavy loading may reinforce a rapid force-production intent and promote neuromuscular adaptations that support forceful lower-limb extension tasks (10, 41).

In summary, these findings suggest that FCT effectively enhances vertical jump, reactive strength, early acceleration, and peak force output. The findings have important implications for sport-specific performance, especially in basketball. In practice, FCT can be scheduled twice per week, with at least 48 hours of recovery between sessions, while movement quality, landing mechanics, fatigue, and recovery status should be carefully monitored given the high neuromuscular demands of this training method.

Limitations

This study has several limitations. First, the participants were limited to male college basketball players, which may restrict the applicability to females. Second, this study did not include physiological and neuromuscular biomarker assessments, which restricts insights into training mechanisms. Future studies should consider more diverse samples and biomechanical and neuromuscular assessments to better clarify the mechanisms.

5 Conclusions

This study suggests that French Contrast Training (FCT) may be a more effective method for enhancing vertical jump, reactive strength, early acceleration, and peak force output than resistance training (RT) in male college basketball players. Future research should confirm these conclusions across diverse samples, and neuromuscular or biomechanical assessments are needed to clarify the adaptations.

Abbreviation

250 RT: Resistance Training
251 F-V: Force-Velocity
252 SSC: Stretch-Shortening Cycle
253 FCT: French Contrast Training
254 CMJ: Countermovement Jump
255 DJ: Drop Jump
256 GCT: Ground Contact Time
257 RSI: Reactive Strength Index
258 IMTP: Isometric Mid-Thigh Pull
259 1RM: One-Repetition Maximum

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263 supervision, and data collection throughout the study period.

264 **Author Contributions**

265 **XD:** Conceptualization, Data curation, Formal analysis, Investigation, Methodology, Project
266 administration, Resources, Software, Supervision, Visualization, Writing—original draft,
267 Writing—review and editing.

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Data availability

The original contributions presented in the study are included in the article; further inquiries can be directed to the corresponding author.

Declarations

Ethics approval and consent to participate

The study was approved by the Ethics Committee of Chongqing University of Education (CQUE-LL20260331009). Informed consent was obtained from all participants before participating in the experiment.

Consent for publication

Not applicable.

Conflict of Interest

The authors declare there are no competing interests.

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Figure Legends

Table 1 Baseline performance outcomes by groups.

Table 2 The effect of the FCT group and the RT group on the explosive performance of participants.

Figure 1 CONSORT flow diagram.

Figure 2 Training protocol.

Figure 3 Effects of FCT and RT on lower-limb explosive performance.

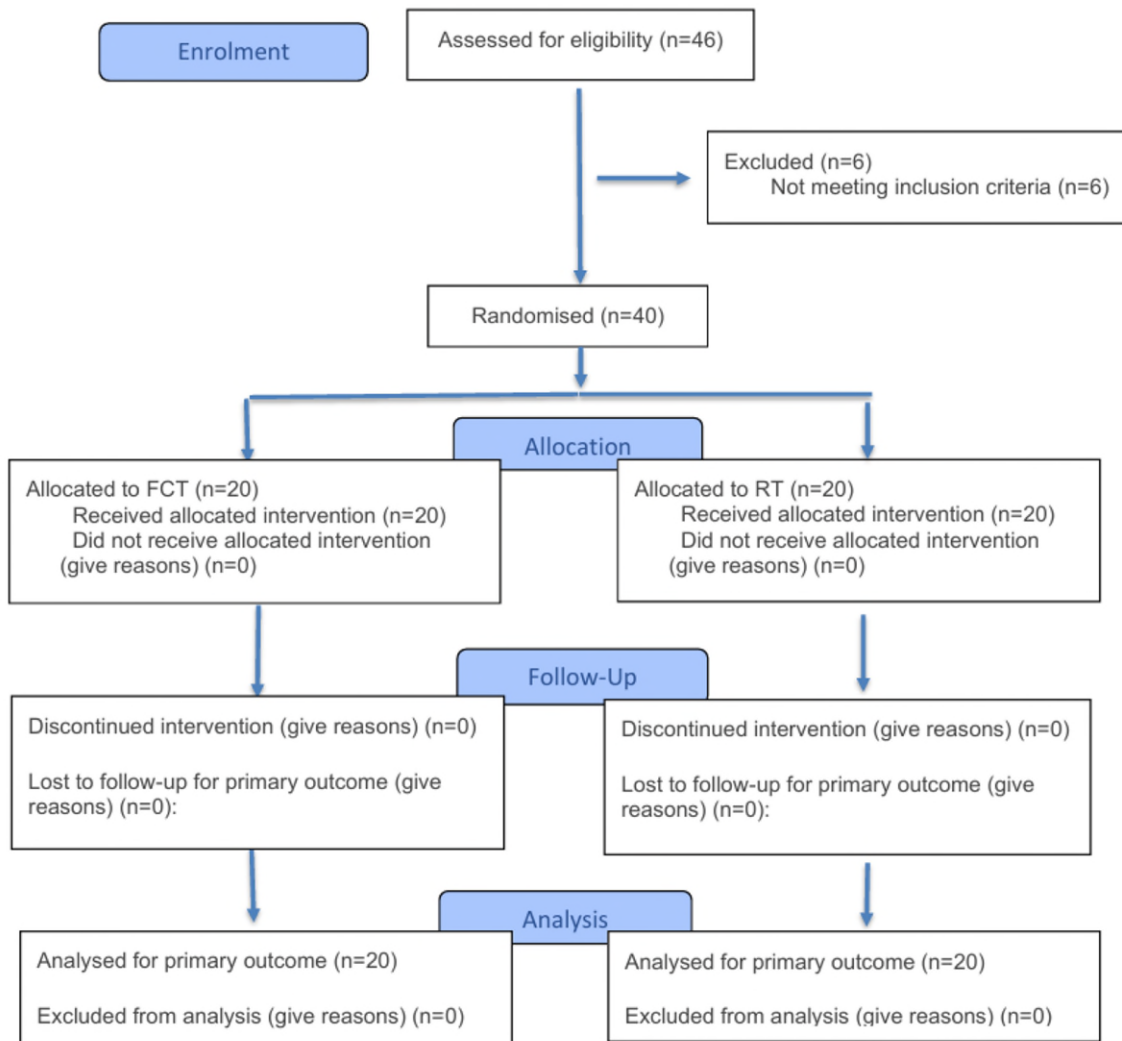


Figure 1 CONSORT flow diagram.

Training Protocol



Duration: 12 weeks



Frequency: 2 sessions/week



Recovery: ≥ 48 h between sessions

FCT Group

1 85% 1RM Squat



20s rest

2 30-cm hurdle jump



20s rest

4 Band-assisted upward jump



20s rest

3 25% 1RM barbell squat jump



RT Group

1 Back squat 85% 1RM



2 Romanian deadlift 85% 1RM



3 Leg press 85% 1RM



4 Walking lunge 30% 1RM



Common Training Dose



4 sets $\times$ 8 repetitions for each exercise



3 min rest between sets

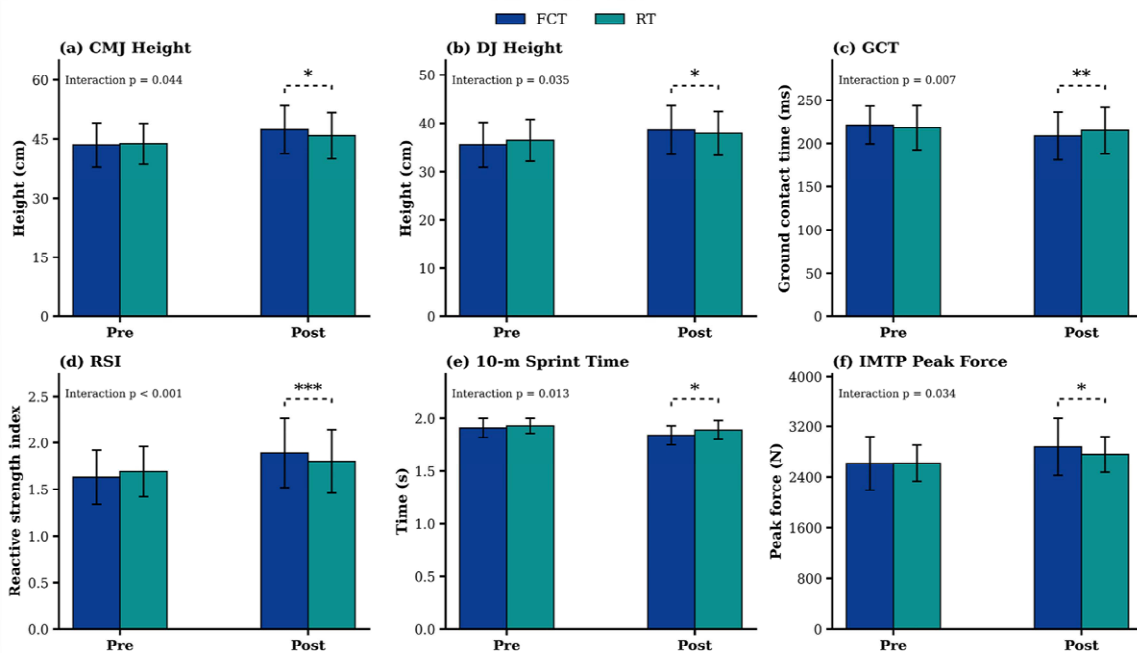


Figure 3 Effects of FCT and RT on lower-limb explosive performance.

*, $p < 0.05$; **, $p < 0.01$; ***, $p < 0.001$.

Table 1 Baseline performance outcomes by groups.

Characteristics	FCT (n=20)	RT (n=20)	t	p
CMJ (cm)	43.51 ± 5.60	43.81 ± 5.18	-0.176	0.861
DJ (cm)	35.55 ± 4.62	36.46 ± 4.31	-0.648	0.521
GCT (ms)	221.20 ± 21.89	218.11 ± 25.49	0.411	0.684
RSI	1.63 ± 0.29	1.69 ± 0.27	-0.738	0.465
10-m sprint time (s)	1.91 ± 0.09	1.93 ± 0.07	-0.763	0.45
IMTP peak force	2615.52 ± 422.39	2618.27 ± 284.32	-0.024	0.981

CMJ, countermovement jump; DJ, drop jump; FCT, French contrast training; GCT, ground contact time; IMTP, isometric mid-thigh pull; RSI, reactive strength index; RT, resistance training.

Table 2 The effect of the FCT group and the RT group on the explosive performance of participants.

Variable	Group	Pre	Post	Δ%	p		
					Time	Group	Interaction
CMJ	Height(cm)						
	FCT	43.51 ± 5.60	47.36 ± 6.10	9.10	<0.001	0.727	0.044
	RT	43.81 ± 5.18	45.84 ± 5.85	4.64			
DJ	Height (cm)						
	FCT	35.55 ± 4.62	38.58 ± 5.05	8.82	<0.001	0.941	0.035
	RT	36.46 ± 4.31	37.88 ± 4.53	4.03			
	GCT (ms)						
	FCT	221.20 ± 21.89	208.57 ± 27.47	5.92	<0.001	0.845	0.007
	RT	218.11 ± 25.49	214.77 ± 26.87	4.64			
	RSI						
10-m sprint	FCT	1.63 ± 0.29	1.89 ± 0.37	15.83	<0.001	0.906	<0.001
	RT	1.69 ± 0.27	1.80 ± 0.34	5.90			
	Time (s)						
	FCT	1.91 ± 0.09	1.84 ± 0.09	3.69	<0.001	0.140	0.013
	RT	1.93 ± 0.07	1.89 ± 0.09	1.72			
	Peak force (N)						
	IMTP	FCT	2615.52 ± 422.39	2873.69 ± 448.99	10.22	<0.001	0.615
RT	2618.27 ± 284.32	2756.36 ± 281.54	5.51				

CMJ, countermovement jump; DJ, drop jump; FCT, French contrast training; GCT, ground contact time; IMTP, isometric mid-thigh pull; RSI, reactive strength index; RT, resistance training; Δ, growth rate.