Rev.int.med.cienc.act.fís.deporte - vol. 22 - número 86 - ISSN: 1577-0354

Zhiguang, W. (2022) Improvement Effect of Different Types of Basketball Specific Motion Training on Athletes' Explosive Strength and Sensitivity Study. Revista Internacional de Medicina y Ciencias de la Actividad Física y el Deporte vol. 22 (86) pp. 513-540
DOI: https://doi.org/10.15366/rimcafd2022.86.019

ORIGINAL

Improvement Effect of Different Types of Basketball Specific Motion Training on Athletes' Explosive Strength and Sensitivity Study

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UNESCO Code / UNESCO Code:
Council of Europe classification / Council of Europe classification:

Recibido 07 de abril de 2021 **Received** April 07, 2021
Aceptado 07 de Abril de 2022 **Accepted** April 07, 2022

Abstract

Leg explosive strength is intimately associated with the ability to change direction. Basketball players frequently complete sprinting, decelerating and changing direction movements on the court, and leg explosive strength is a prerequisite for completing high-intensity explosive movements. Athletes' agility relies on single-leg power in the vertical and horizontal directions to adjust the body to complete braking and deceleration, support transition, and re-acceleration, and the content of unilateral super-equal-length training is to a certain extent in line with the mechanical characteristics and forms of muscle contraction in the process of change of direction. However, few studies have investigated the effects of unilateral and bilateral isometric training on the unilateral and bilateral explosive force and change of direction ability of basketball players. In this paper, we used an experimental method to investigate the effects of 8 weeks of uni- and bi-lateral super isometric training of the lower limb on the explosive power and agility of the legs of basketball players. The results of intra-group leg explosive strength test before and after the experiment showed that the difference between the experimental group before and after the intervention was significant ($P<0.05$) in unilateral reverse jump, bilateral reverse jump, unilateral reaction strength index, and bilateral reaction strength index scores; the difference between the control group before and after the intervention was significant ($P<0.05$) in bilateral reverse jump and bilateral reaction strength index scores. Comparison of the leg explosive strength results between the groups after the experiment showed that the two groups interacted significantly only in the left reverse jump ($P<0.05$), and there was no significant interaction in the other test results ($P>0.05$).

Keywords. Explosive Strength, Sensitivity Study, Basketball Specific Motion Training

1. INTRODUCTION

Basketball, as a speed-power, confrontational skill sport with fast and variable offense and defense for the purpose of shooting (Abdelkrim, Castagna, El Fazaa, & El Ati, 2010), basketball players execute up to 835 change of direction movements in a game (Sheppard & Young, 2006), and adolescent basketball players complete 1 change of direction movement in about 2-3 seconds (Robinson & O'Donoghue, 2008), of which, 450 lateral movement movements are completed . Soccer players need to complete about 726 changes of direction in a game, and more than 95% of the sprints are less than 10 m, of which 76% are less than 5 m, which highlights that the ability to complete high-intensity change of direction movements under rapid offensive and defensive transitions is one of the key factors affecting the level of competitiveness, which is necessary for the team to achieve the victory in the game. Leg explosive strength is closely related to change of direction ability , and developing leg explosive strength is one of the effective ways to improve change of direction ability. Falch et al summarized and compared 74 studies on the effects of super isometric training, resistance strength training, sprinting exercises, nonlinear mobility training and combination training on leg muscle strength and change of direction ability, and were still unable to determine the most effective training method for developing change of direction ability (Nygaard Falch, Guldteig Rædergård, & van den Tillaar, 2019).

Based on the study of the mechanical mechanism of the change-of-direction action process, the 45° and 90° tangent processes both showed obvious mechanical differences in the vertical and horizontal directions (Havens & Sigward, 2015). Comparing the mechanical characteristics of the change-of-direction process at different angles, there are obvious differences between the 45° cut and 90° cut in terms of vertical, posterior and lateral driving forces, among which, the 90° cut performance is influenced to a certain extent by the internal and external ground reaction forces and the horizontal direction of the explosive force. Marshall et al pointed out that different angles of entry may have different effects on the activation level of lower limb medial and lateral muscles (Marshall et al., 2014), and the process of change of direction mainly relies on the single leg to generate braking and pushing forces in the vertical and horizontal directions, and to adjust the body's braking and deceleration as well as re-acceleration to complete the change of direction (Brughelli, Cronin, Levin, & Chaouachi, 2008).

In terms of the form of muscle contraction, a large number of on-course movements show a form of muscle contraction involving centrifugal and centripetal transitions, and few muscle tissues unidirectionally involve centrifugal, isometric, or centripetal contractions. The Stretch-ShorteningCycle (SSC) mechanism involving centrifugal and centripetal transitions can improve performance by 10%-15% by virtue of the storage and reuse of elastic potential energy compared to centripetal contraction alone (Turner & Jeffreys, 2010). The process of change of direction mainly consists of unilateral braking and cushioning, support transition and repowering, which is closer to the centrifugal and centripetal transition process of the SSC in unilateral super-equal-length training. Wang Feng et al recruited male tennis players to verify the effects of 4 weeks of unilateral jumping fence training on lateral movement and sprinting ability, and pointed out that unilateral jumping fence training helps to improve lateral starting speed and sprinting ability (Feng Wang, Zhihua Zhang, & CHEN Fangfang, 2019).Hyper-equal length training has been shown to enhance neuromuscular control and change of direction ability (Asadi, Arazi, Young, & de Villarreal, 2016), and this paper aims to investigate the effects of unilateral and bilateral hyper-equal length training of the lower limb on the explosive power of the leg and change of direction sensitivity of basketball players through training experiments.

2. Related works

2.1 Status of Research on Unilateral and Bilateral Training of the Lower Extremity

Young reported that bilaterally vertically oriented exercise components (vertical jump, deep squat, hard pull & Olympic lifts) produced a weak training effect on elite level athlete populations, despite the fact that bilaterally resisted strength training was effective in developing maximal strength, however, bilaterally induced low effects on the migration of athletic performance for elite level athlete populations (Young, 2006). Cronin et al noted that back squat maximal strength (23%-27%) had a low migratory effect (2-3%) on sprinting ability for a population of athletes (Cronin, Ogden, Lawton, & Brughelli, 2007). When comparing the effects of interventions in different groups of athletes at different levels, amateur groups of athletes typically show positive and significant intervention effects, in contrast to high level groups of athletes who show lower intervention effects. Considering that high-level athletes have many years of training experience, in order to further improve the performance of specialties, the training content should be developed according to the characteristics of the mechanics of specialties, the characteristics of the energy supply system, and the form of muscle contraction, etc. Compared with the content of bilateral exercises, unilateral exercises are more in line with the principles of specialties, and they can produce a positive effect on the transfer of sports performance.

The concept of Bilateral Force Deficit (BFD) was first proposed in 1961 (Henry & Smith, 1961), when two homologous limb muscles contract simultaneously, the maximum force produced by one limb will be reduced, i.e., the level of force output from a bilateral muscle contraction is less than the sum of the forces produced by unilateral (left and right) muscle contractions. Kuruganti et al pointed out that 6 weeks of bilateral training significantly reduced bilateral strength deficit in adolescent group and middle-aged and elderly group, similarly (Kuruganti, Parker, Rickards, Tingley, & Sexsmith, 2005), Taniguchi et al compared the effects of 6 weeks of unilateral and bilateral training on bilateral strength deficit, and pointed out that the short-term unilateral training not only failed to reduce the bilateral strength deficit, but also enhanced it (Taniguchi, 1997), which is the same as the previous study. Currently, the relationship between bilateral strength deficit and athletic performance and injury risk is still unclear; therefore, coaches should not consider how unilateral and bilateral training affects bilateral strength deficit, but should focus their training on enhancing unilateral and bilateral muscle strength.Häkkinen et al stated that before and after bilateral strength training, the maximal strength of the bilateral group group increased by 19%, and the strength of the left and right legs of the bilateral group group increased by 11% and 10%, respectively (Häkkinen et al., 1996). After unilateral strength training for the unilateral group group, their maximal strength improved by 13%, and the left and right leg strength of the unilateral group group improved by 14% and 17%, respectively, and unilateral and bilateral training positively affected unilateral and bilateral strength, respectively.

Makaruk et al divided 49 female basketball players into a unilateral horizontal hyper-equalization training group and a bilateral vertical hyper-equalization training group (Makaruk, Winchester, Sadowski, Czaplicki, & Sacewicz, 2011). After 8 weeks of training, only the unilateral group significantly improved peak explosive strength, and a shorter period of unilateral hyper-equalization training (<8 weeks) was more effective than bilateral hyper-equalization training in improving peak explosive strength. After a 4-week break in training, the bilateral group showed a significant increase in peak explosive power before and after the 12-week intervention (P<0.05). However, the peak explosive power of the unilateral group decreased significantly (P<0.05) after 4 weeks of training cessation. Although unilateral training led to significant neuromuscular adaptations in a shorter period of time, the intervention effect was of shorter duration, and bilateral training failed to produce more positive neuromuscular adaptations in the short term, however, the intervention effect of bilateral training was of longer duration.

Sun Zhao conducted 8 weeks of unilateral and bilateral strength training on U15 national female basketball players (Sun Zhao, 2017), and pointed out that the unilateral group group significantly improved the performance of single-leg vertical jump and assisted double-leg vertical jump (P<0.05), and the bilateral group group only improved the performance of double-leg vertical jump (P<0.05), and the unilateral resistance strength training positively affected the lower limb unilateral and bilateral explosive power. Que Yilin randomly divided 23 soccer players into unilateral compound training group, bilateral compound training group (Que Yilin, 2020), and specialized training group, after 6 weeks of intervention, the unilateral group group significantly improved the T-test (P<0.01) and reverse jump (P<0.05). Compared with the bilateral group, the unilateral group significantly improved the T-test (P<0.05) and the total peak flexor-extensor muscle of the left knee at 180 degrees/s (P<0.05), and the neuromuscular adaptation effect of unilateral complex training was better than that of bilateral complex training.

The choice of movement can directly affect the training effect and competitive performance of athletes, and the choice of training method can cause differential adaptive effects in the body, with unilateral and bilateral training enhancing and weakening the phenomenon of bilateral strength deficits, respectively. Shorter cycles (<8 weeks) of unilateral training produced more positive neuromuscular adaptations than bilateral training, however, bilateral training was more effective than unilateral training in sustaining the training effect over a longer period of time.

2.2 Explosive strength of leg

Explosive strength refers to the rapid contraction of muscles to output maximum force in a relatively short period of time, Sheppard et al pointed out that explosive strength is one of the important muscular factors affecting the ability to change direction in their study of the leg muscular modeling that constitutes the ability to change direction. Naruhiro et al explored the relationship between explosive leg strength and change of direction ability in a group of rugby players (Hori et al., 2008), noting that the reverse jump was moderately correlated with 5m folding performance (r=-0.42). Vescovi et al reported that female athlete group reverse jump was moderately to highly correlated (r=-0.47--0.69) with Illinois, Pro agilty scores (Vescovi & Mcguigan, 2008).

Naruhiro et al used a weighted (40kg) reverse jump to assess peak explosive strength and relative peak explosive strength of the lower limb (Hori et al., 2008), and the change of direction index used a 180° 5m folding run, and the results showed that the peak explosive strength and relative explosive strength levels of the weighted reverse jump were moderately correlated with the 5m folding and change of direction performance (r = -0.38 - -0.49).

Various indicators are used to assess change of direction ability, and factors such as cutting angle, number of changes of direction, and running distance affect change of direction performance to a certain extent, which may lead to differences in the results of the correlation between change of direction ability and leg explosive strength, and most of the research results indicate that leg explosive strength and change of direction performance show a moderate to high correlation, and that leg explosive strength is an important factor that affects the change of direction ability.

2.3 Leg Reaction Strength

Reaction force is the ability of a muscle to store elastic potential energy through centrifugal elongation and output force through rapid centripetal contraction during SSC. Sheppard et al, in their study on the leg muscle strength model that constitutes the ability to change direction, pointed out that reaction force is an important muscle strength factor that affects the ability to change direction. Reaction force index can be used as a test index to assess reverse strength, which can be measured by the deep jump maneuver, and the reaction force index can be described as the ratio of the height of the deep jump to the touchdown time (Flanagan, Ebben, & Jensen, 2008).

Based on the centrifugal-to-centripetal coupling transition time (0.25s), SSC can be categorized into Fast SSC and Slow SSC, and the reverse jump and deep jump can assess Slow SSC and Fast SSC, respectively. There is a relationship between the support transition time and the angle of entry during the change of direction maneuver.

The angle of entry affects the contact time between the support foot and the ground during the transition, and the support transition time for a small angle of entry <75° is usually less than 0.25s, while the support transition time for a large angle of entry >75° is usually more than 0.25s due to the large braking requirement.

Barnes et al. compared the relationship between the two SSC movement patterns and change of direction performance and showed that the correlation coefficient between the 30cm deep jump performance and the smaller angle change of direction performance was greater than the coefficient between the 30cm deep jump performance and the larger angle change of direction performance, and that the level of reaction force had a greater effect on the smaller angle change of direction performance than the larger angle change of direction performance (Barnes et al., 2007).

In summary, there was a higher correlation between reaction force and small-angle (<75°) change-of-direction performance compared with large-angle change-of-direction performance (>75°); the correlation coefficient between unilateral reaction force and change-of-direction ability was usually greater than the correlation coefficient between bilateral reaction force and change-of-direction ability, and unilateral reaction force affected change-of-direction ability to a greater extent than bilateral reaction force.

2.4 Lower Limb Strength Asymmetry

Lower limb asymmetry in sports includes the phenomena of joint mobility, flexibility, lower limb length, strength, etc. In this study, lower limb asymmetry mainly refers to the asymmetry of lower limb muscle strength. The braking and deceleration, support transition, and re-acceleration processes in change of direction mainly rely on the single leg to overcome self-weight and moment, therefore, the braking and deceleration, support, and stomping processes may be affected by the lower limb dominant side and non-dominant side muscle strength.

Bailey et al pointed out that there was a significant correlation between lower limb asymmetry and jumping performance ($r=-0.34$--0.52, $P<0.05$), and that lower limb asymmetry was an important factor affecting jumping performance (Bailey, Sato, Alexander, Chiang, & Stone, 2013). Hoffman et al explored the relationship between dominant and nondominant side muscle strength and dominant and nondominant side change of direction ability (Hoffman, Tenenbaum, Maresh, & Kraemer, 1996), and noted that the difference between dominant and nondominant side change of direction ability of the lower limb was significant ($P<0.05$), however, there was no significant correlation between muscle strength asymmetry and overall change of direction performance.

Meylan et al incorporated directional variables into the study of change of direction ability and noted that jumping ability in the horizontal direction of the dominant and non-dominant sides was highly correlated with change of direction ability ($r=-0.47$--0.59) (Meylan et al., 2009), indicating that explosive force in the horizontal direction of the dominant and non-dominant sides is an important factor influencing change of direction ability. Spiteri et al compared the change-of-direction performance of groups with different strength levels and noted that the stronger group showed a significant mechanical advantage during change-of-direction compared to subjects with weaker muscular strength (Spiteri, Cochrane, Hart, Haff, & Nimphius, 2013).

The lower limb asymmetry in this study mainly refers to the imbalance of muscle strength between the dominant and non-dominant sides of the leg. The muscle strength asymmetry phenomenon may lead to a different degree of influence on the change of direction ability of the dominant and non-dominant sides, with the stronger side of the muscle strength usually outperforming the weaker side of the muscle strength in the change of direction performance; however, the muscle strength asymmetry phenomenon in the lower limb does not limit the overall change of direction performance.

3. Different types of strength training programs

3.1 Training Objects

Twenty healthy male students majoring in basketball sports training at the School of Physical Education and Sports of Jiangxi Normal University, all with more than 4 years of training, were required to have no history of serious lower limb disorders in the past three months, and to voluntarily participate in this intervention experiment after being trained by the testers and familiarizing themselves with the testing requirements and procedures.

The 20 trainers were divided into an experimental group and a control group of 10 each, with the experimental group arranging unilateral super-equal length training of the lower limbs and the control group performing bilateral super-equal length training of the lower limbs. The basic information of the subjects is shown in Table 1.

Table 1. Information on training objects

Subjects	Height（cm）	Weight（kg）	BMI（kg/m2）	Age（yr）
Experimental group	185.6±3.63	79.95±6.56	23.22±1.58	20.6±1.51
control group	186.1±4.06	80.71±5.02	23.28±7.48	20.4±1.35

3.2 Time and place of training

Training time: early September 2022 - mid-November 2022, 10 weeks, including 1 week of pre-test and 1 week of post-test, 8 weeks of experimental time, 2 times/week (Tuesday and Friday mornings), single training session of 45 minutes duration.Training Location: Jiangxi Normal University Gymnasium

3.3 Training program design

3.3.1 Training intervention programs

The arrangement of the training contents of the experimental and control groups are shown in Tables 2 and 3, respectively.

Table 2. Contents of unilateral super isometric training of the lower limb in the experimental

group

Intervention period		Experimental group training content	No.	times
Week 1 - Week 2 (Phase 1)	Vertical	Single leg long jump, jump stop	2	4
		Single leg deep jump, jump stop	2	4
	Horizontal	Single leg inward fence jump, jump stop	2	4
		Single leg outward jump, jump and stop	2	4
	Forward	Single leg forward jump, jump and stop	2	4
		Single leg forward long jump, jump and stop	2	4
Week 3 - Week 5 (Phase 2)	Vertical	Single leg jumps with small bounces	2	4
		Single leg deep jumps with small bounces	2	4
	Horizontal	Single leg inward jump with a small bounce	2	4
		Single leg outward jump with a small bounce	2	4
	Forward	Single leg forward with a small bounce	2	4
		Single leg forward long jump with a small bounce	2	4
Week 6 - Week 8 (Phase 3)	Vertical	Single leg jumps	2	4
		Single leg deep jump	2	4
	Horizontal	Single Leg Inward Continuous Hurdles	2	4
		Single leg outward jump	2	4
	Forward	Single leg forward jump	2	4
		Single leg forward long jump	2	4

Table 3. Contents of bilateral super isometric training of the lower limbs in the control group

Intervention period		Experimental group training content	No.	times
Week 1 - Week 2 (Phase 1)	Vertical	Double leg long jump, jump stop	2	4
		Double leg deep jump, jump stop	2	4
	Horizontal	Double leg inward fence jump, jump stop	2	4
		Double leg outward fence jump, jump and stop	2	4
	Forward	Double leg forward jump, jump and stop	2	4
		Double leg forward long jump, jump and stop	2	4
Week 3 - Week 5 (Phase 2)	Vertical	Double leg jumps with small bounces	2	4
		Double leg deep jumps with small bounces	2	4
	Horizontal	Double leg inward jumps with small bounces	2	4
		Double leg outward jumps with small bounces	2	4
	Forward	Double leg forward jump with a small bounce	2	4
		Double leg forward long jump with a small bounce	2	4
Week 6 - Week 8 (Phase 3)	Vertical	Double-legged continuous vertical jump	2	4
		Double leg deep jump	2	4
	Horizontal	Double leg inward continuous jump	2	4
		Double leg outward jump	2	4
	Forward	Double leg forward jump	2	4
		Double leg forward long jump	2	4

3.3.2 Arrangement of training experiment interventions

In this study, we used the "unilateral and bilateral super-equal length training" method to test the effect of two different methods on the explosive power and change of direction of the legs. The training period was 10 weeks, 1 week for pre-test and 1 week for post-test, and the actual training period was 8 weeks, with 2 training interventions per week. The 8-week training cycle was divided into 3 phases, with "week 1 - week 2" as the first phase, "week 3 - week 5" as the second phase, and "week 6 - week 8" as the third phase.

Previous studies have shown that hyper-equalization training requires high neuromuscular excitability, and in order to ensure the intervention effect of hyper-equalization training, the duration of the intervals between hyper-equalization training sessions should be more than 48 hours. The negative effect of fatigue on the effectiveness of the intervention can be eliminated with two sessions of hyperlength training per week. The amount of hyperlength training can be measured by counting the number of times the foot touches the ground, with the number of unilateral touches being half the number of bilateral touches. The number of sessions should be 80-120. To ensure the effectiveness of the training, the total number of sessions for both the experimental group (unilateral isometric training) and the control group (bilateral isometric training) was 96, and the intensity of the training was gradually increased according to the training phase. In view of the fact that the orientation factor can cause differential effects on neuromuscular adaptation, the process of change of direction requires the lower limbs to exert force in multiple directions to complete. In order to avoid the negative influence of the orientation variable on the experimental intervention, the experimental group and the control group performed super-equal-length training in the vertical, lateral, and forward directions, with 4 sets in each direction, for a total of 12 sets of 6 repetitions each, for a total of 96 repetitions per set, with a 2-minute interval between sets. The only differences between the two groups were in the pattern of unilateral and bilateral jumps and unilateral and bilateral jump stops.

The jumping movement requires the subjects to complete it with maximum effort, keep the waist and abdomen tight during the jumping process, and fully extend the hip, knee and ankle joints; compared with previous studies, this study focuses on the development and consolidation of post-jump stopping posture after jumping, i.e., the ability to control the body posture in the landing phase, which lays the foundation of centrifugal force and movement technique for the subsequent training phase. A scientific and stable landing posture can improve athletic performance and reduce the risk of lower limb injury. The jump-stop action requires a high degree of coordination of the lower limb hip, knee and knee muscles. There are three specific movement requirements:

First, the athlete is required to do a hip joint-led flexion in the landing phase, and the squatting position can be lower than the height of the femur parallel to the ground;

Secondly, the subjects were required to avoid excessive forward extension of the knee joint during the landing squatting process;

Finally, the jump-stop maneuver requires the subject to rapidly complete hip, knee and ankle flexion during the landing process, in order to land as "softly" as possible.

The height of 30cm-40cm is the best height interval for basketball players to perform deep jump practice, the experimental group and the control group in the single and bilateral deep jump practice height of 30cm; single and bilateral multi-directional jumping fence height of 15cm, 30cm, respectively, the height of the single and bilateral multi-directional jumping fence height of 15cm can ensure the quality of training, to avoid the excessive height of the fence to produce psychological concerns; the single and bilateral fence placed horizontally spacing is 50cm.

3.3.3 Training process organization

(i) Preparatory segment

The preparation part aims to mobilize the organs of the body, gradually awaken the body, and make full preparations for reaching the optimal exercise state. Lower limb isometric training has the action characteristics of short action time, high intensity, and many muscle groups involved. Compared with the lower intensity exercise activities, isometric training requires higher excitability of the nervous system, and requires a longer period of exercise preparation to wake up the body and realize the optimization of the exercise performance.

The preparation section was performed uniformly by both groups, during which two fitness instructors assisted in guiding, demonstrating, and supervising the preparatory movements. The main content of the preparation part includes jogging warm-up and dynamic stretching.

(ii) Division of experimental intervention phases and content organization

1) Phase I (Week 1 to Week 2)

The first phase of the training experiment lasted 1-2 weeks. The number of jumps in both groups was 96, and the subjects were required to complete the jumping and stopping maneuvers with maximum effort, ending with a single-leg stop after a single-leg jump and a double-leg stop after a double-leg jump.

The first phase of training emphasized the landing technique after jumping to improve centrifugal force and body posture control, and laid the foundation of movement technique for the subsequent phase of super isometric training. During the training session, the physical trainer observes the athletes' jumping and stopping landing postures from the front and the side, and instructs the athletes to complete high-quality jumping and stopping movements.

The experimental group performed unilateral multi-directional jumping maneuvers with 4 sets of unilateral super-equal length exercises in each direction; the control group performed bilateral multi-directional jumping maneuvers with 4 sets of bilateral super-equal length exercises in each direction. In the experimental group, the training content included 3 directions (vertical, lateral and forward), the vertical exercise included single-leg long jump, hopping stop and single-leg deep jump, hopping stop, the lateral exercise involved single-leg outward hopping and hopping stop and single-leg inward hopping and hopping stop, and the forward exercise included single-leg forward hopping and hopping stop and single-leg forward long jumping and hopping stop. In the control group, the same 3-direction bilateral isometric training was performed (vertical, lateral, and forward), with 4 sets of exercises in each direction. Vertical exercises consisted of double-leg long jumps, skipping stops, and deep jumps, skipping stops; lateral exercises involved double-leg inward skipping, skipping stops, and double-leg outward skipping, skipping stops; and forward exercises consisted of double-leg forward skipping, skipping stops, and breaststroke skipping, skipping stops. The interval between sets is 2 minutes.

2) Phase II (weeks 3 to 5)

The training volume of both groups was 96 repetitions, the same as that of phase 1, and the intensity of the second phase was increased. The first phase of training emphasized the centrifugal cushioning of the landing posture after the maximal effort jump, in order to develop the subject's postural control and centrifugal cushioning ability. The second phase builds on the first phase by requiring the subject to complete one small bounce before the maximal effort jump, and the small bounce before the maximal effort jump is not included in the training volume. In this phase, the small jumps with stretch cycle mechanism (SSC) were added and introduced, and the subjects successively completed small jumps, maximum effort jumps and jumping stops, which could increase the stretching load borne by the muscles and connective tissues, and the jumping stops required the same as that in the first phase, which could further consolidate the landing posture and the postural control ability of the body.

In the second phase, 4 sets were performed in each of the three directions (vertical, lateral and forward), with the same methodology as in the first phase, except for the difference in unilateral and bilateral force generation and the addition of a small bounce before each jump. The interval between sets was 2 minutes.

3) Phase III (weeks 6 to 8)

The number of jumps in the third phase was 96 for both groups, and the intensity of training was again increased incrementally from the second phase. Compared with the second phase, the third phase did not have a small bouncing movement before jumping, and the subjects were required to complete the jumping movement continuously with maximum effort, minimize the time of expansion and contraction cycle and touchdown time, and finally end the set of exercises with single-leg and double-leg jumping and stopping body postures. The content of the jumping method was the same as in the previous phase. The interval between sets was 2 minutes.

(iii) Organize relaxing stretches

Static stretching is necessary to relax after isometric training because repeated contraction of muscle tissue results in many muscle fibers not being able to return to their pre-training length. Static stretching helps to lengthen the initial length of muscle tissue, improves flexibility and joint mobility, and makes it easy for athletes to obtain good biomechanics during exercise, which facilitates the application of greater loads to the muscles, and improves the force generated and withstood by muscle contraction. Static stretching does not produce more movement or acceleration of the body, and does not cause the onset of the tension reflex action.

Post-training static stretching can be the main component of the recovery and regeneration process of the athlete, and this part mainly takes the form of active static stretching. Active static stretching refers to the athlete to participate in the static stretching of the muscle groups with the help of their own, lengthening the muscle to a defined position and hold a period of time, this part of the main lower limb muscle groups for stretching, stretching time is 30s. The flow chart of the training phase is shown in Figure 1.

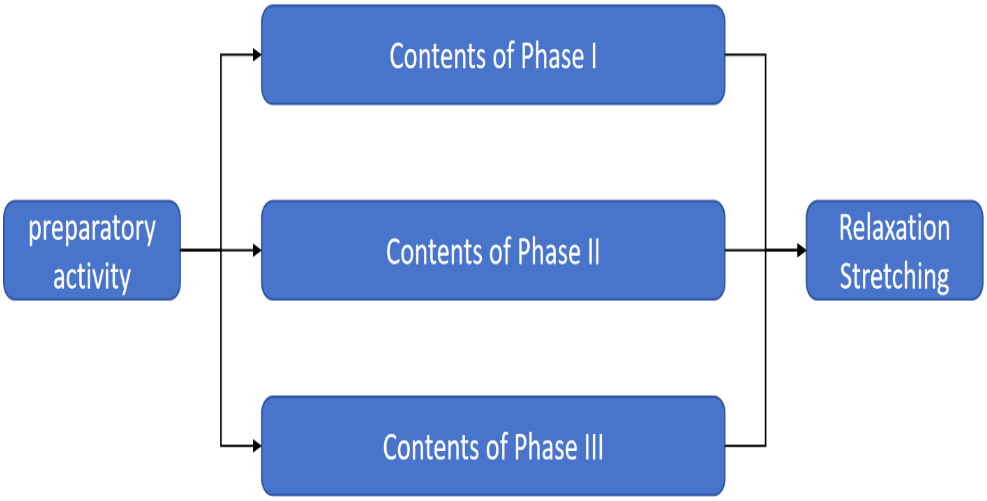

Figure 1. Training Flowchart

3.3.4 Control of training conditions

(1) The training time is uniformly arranged on Mondays and Thursdays at 3:00 p.m. to ensure the consistency of the training experiment time.

(2) During the training experiment, the subjects were required to wear sportswear and basketball shoes in order to better conduct the training experiment and to avoid the negative impact of clothing and shoe factors on the training experiment.

(3) Organize 3 coaches with physical training qualifications to demonstrate and instruct the subjects, so that the subjects are familiar with the experimental process, methods and contents. 2 coaches will lead the experimental group and the control group to conduct the training experiment, and 1 physical trainer will go around to supervise and instruct the subjects, so as to reduce the negative impacts caused by the inconsistency of the

technical movements.

4. Experimental testing

4.1 Testing equipment

(1) Optojump test system (Optojump, Microgate, Australia), produced by Microgate, Italy, can be used for physical fitness and technical movement testing, evaluation, can accurately assess the sprinting, jumping, reaction, balance and other physical abilities. The Optojump test system consists of a 1 meter transmitter, a receiver and a computer with Optojump software.

Figure 2. Optojump Test System

(2) The Smartspeed test system, produced by the Australian company Fusion Sport, is a training device specialized in the evaluation of several physical qualities of athletes, such as speed, agility, reflexes, etc. It is a systematic tool for research, training, coaching and testing. The Smartspeed test system consists of a Bluetooth receiver, infrared emitters, reflectors and a stand, and is used in conjunction with an Ipad with specialized software.

(a)

(b)

Figure 3. Smartspeed test system and Ipad tablet computer

(3) Other experimental equipment: electronic scales, tape, tape measure, 30cm jump box and 15cm, 30cm height of each of the six columns

4.2 Time and place of testing

Testing time: one week before and after the experiment to complete the test, the pre-test was completed in mid-September, and the post-test was completed at the end of November.

Test site: Jiangxi Normal University Gymnasium

4.3 Test items

4.3.1 Leg Explosive Strength Tests

(1) Unilateral and bilateral Countermovement jumps

Table 4. Unilateral and bilateral Countermovement jumps

Test Content	Test Purpose	Test Method
Unilateral Countermovement Jump,UCMJ	To evaluate the intervention effect of unilateral and bilateral super isometric training on unilateral centrifugal and centripetal explosive strength of the lower extremity in basketball players.	Test and calculate the vacated height using the Optojump instrument. Countermovement jump height calculation formula: $Height = \frac{gt^2}{8}$
Bilateral Countermovement Jump,BCMJ	Evaluating the effect of unilateral and bilateral super isometric training on the intervention of bilateral centrifugal and centripetal explosive strength in the lower extremities of basketball players.	

The unilateral and bilateral Countermovement jump tests are shown in Table 4.The unilateral and bilateral Countermovement jumps can be used to assess unilateral and bilateral leg explosive power. The Countermovement accomplishes the maximum power output in a short period of time through the use of SSC and the tension reflex mechanism. Unilateral and bilateral Countermovement jumps were collected using the Optojump instrument.

(2) Unilateral and bilateral reactive strength indexes

Table 5. Unilateral and bilateral reactive strength index

Test Content	Test Purpose	Test Method
Unilateral Reactive Strength Index, URSI	Evaluating the effectiveness of unilateral and bilateral super isometric training interventions on left and right lateral reactive strength of the lower extremity in basketball players.	The Optojump instrument is used to test and calculate the ratio of unilateral and bilateral free time to touchdown time of basketball players. Reactive strength index formula : $RSI = \frac{Height(m)}{Time(s)}$
Bilateral Reactive Strength Index, BRSI	Evaluating the effectiveness of unilateral and bilateral super isometric training as an intervention for bilateral reactive strength of the lower extremity in basketball players.	

The contents of unilateral and bilateral reactive strength index tests are shown in Table 5.

Reactive strength index can effectively assess the level of reactive strength, reactive strength index can be expressed as the ratio of jump height and touchdown time, the higher the jump height and the shorter the touchdown time after a deep jump, the better the performance of reactive strength index. In this study, the Optojump instrument was used to collect unilateral and bilateral reactive strength index scores.

(3) Lower-body Asymmetry index

Table 6. Lower-body Asymmetry index

Test Content	Test Purpose	Test Method
Lower-body Asymmetry index, ASL	Evaluating the effectiveness of unilateral and bilateral super isometric training as an intervention for lower body asymmetry in basketball players.	The left and right Countermovement jump scores of basketball players were collected using the Optojump instrument and substituted into the asymmetry index formula for calculation, respectively: $ASL = \frac{2\lvert L-R \rvert}{(L+R)} \times 100\%$ L indicates left Countermovement jump height and R indicates right Countermovement jump height.

Lower body asymmetry index is an absolute value asymmetry index, which is calculated according to the asymmetry index formula of Maines et al. with L indicating the left Countermovement jump height of the lower limb, and R indicating the right Countermovement jump height of the lower limb, and then substituting them into the formula, respectively (Maines & Reiser, 2006). Absolute value asymmetry index does not distinguish between the dominant side and the non-dominant side, but only focuses on the size of the difference between the two sides, i.e., The absolute value of the difference between the two sides, and the smaller the index, the better the performance of functional asymmetry of the lower limbs, and the worse the performance of the opposite.

4.3.2 Sensitivity testing

(1) Left and right change of direction deficits

Table 7. Left and right side change of direction deficits

Test Content	Test Purpose	Test Method
Left Change of Direction Deifict, LCODD	Evaluation of the effects of unilateral and bilateral super isometric training on left-sided sensitivity in basketball players.	Total time for a basketball player to complete a change of direction on the left or right side of the lower extremity is captured using the SmartSpeed instrument.
Right Change of Direction Deifict, RCODD	Evaluation of the effect of unilateral and bilateral super isometric training on the intervention of right lateral change of direction.	

The content of the left and right change of direction deficit test is shown in Table 7, and the flow of the test route is shown in Figure 5. sensitivity refers to the ability to change the speed and direction of the movement quickly under the condition of anticipating the direction, which includes the process of decelerating, changing direction and accelerating again in a relatively short period of time. The change of direction deficit is defined as the difference between the 505 test time and the 10m sprint time, and there is a high correlation between the 505 test and the sprint (r=-0.52-0.7), and a weak correlation between the change of direction deficit and the sprint performance (r=-0.11-0.1), which explains 89% of the change of direction performance, and the change of direction deficit index is more effective in assessing the sensitivity. The course of the change of direction deficit test is shown in Figure 4.

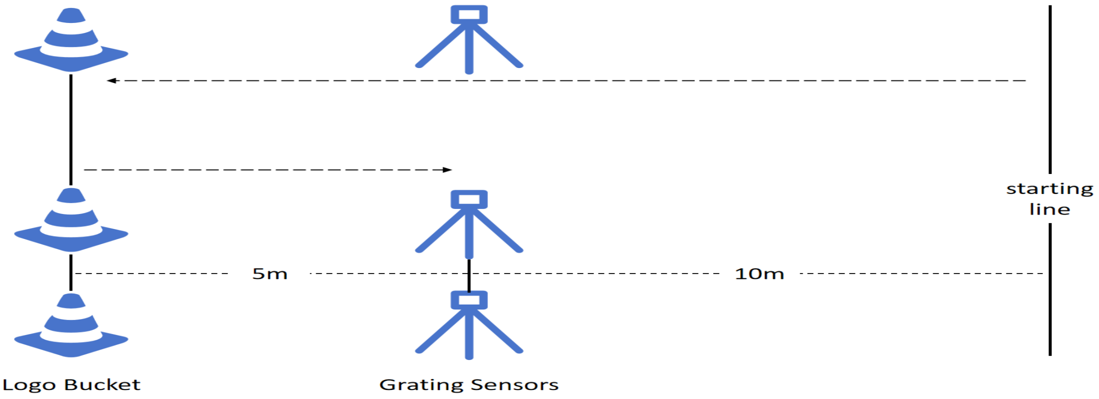

Figure 4. Change of direction deficit

(2) V-cut

Table 8. V-Cut

Test Content	Test Purpose	Test Method
V-cut	Evaluation of the intervention effect of unilateral and bilateral super isometric training on basketball-specific sensitivity.	Total time of the basketball player's lower extremity change-of-direction maneuver process was captured using a SmartSpeed instrument.

The test content of V-cut is shown in Table 8, and the test route is shown in Figure 5. Basketball players frequently perform 45°±15° change of direction cuts, and the V-cut is close to the basketball-specific change-of-direction performance, and the test content includes 4 times of cuts, with 5m sprinting and decelerating process in each cut, and the running distance is 25m. The V-cut is mainly affected by the anaerobic energy supply system, which is closer to the characteristics of basketball players' specialized movements and energy system, and the V-cut can effectively evaluate the basketball specialized sensitivity (ICC=0.87-0.95; CV=1.2%-1.4%).

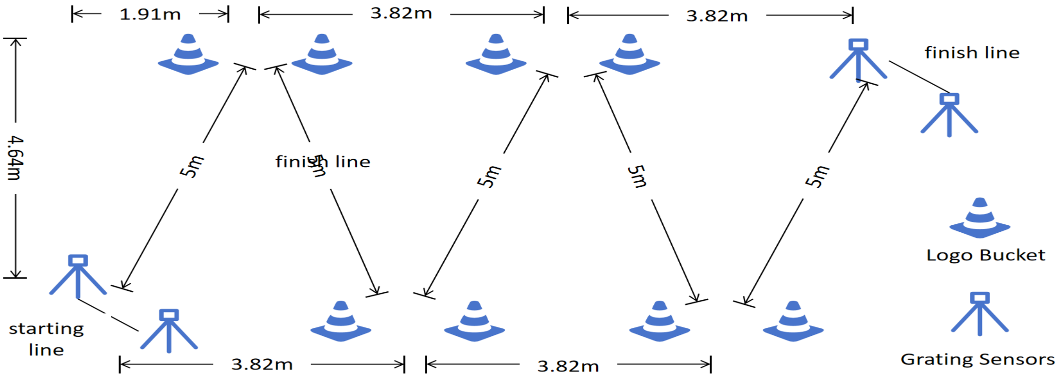

Figure 5. V-cut

5. Analysis of test results

5.1 Comparison of test scores between experimental and control groups before training

Table 9. Results of the pre-test normal distribution test for the experimental and control groups

Pre-testing project	Shapiro-Wilk test	Pre-testing project	Shapiro-Wilk test
Experimental group left side Countermovement jump	0.811	Experimental group reactive strength index	0.459
Control group left side Countermovement jump	0.427	Control group reactive strength index	0.268
Experimental group right side Countermovement jump	0.723	Experimental group lower body asymmetry index	0.373
Control group right side Countermovement jump	0.840	Control group lower body asymmetry index	0.561
Experimental group bilateral backward jump	0.096	Experimental group V-cut	0.069
Control group bilateral Countermovement jump	0.501	Control group V-cut	0.813
Experimental group left side reactive strength index	0.958	Experimental group left side change of direction deficit	0.385
Control group left side reactive strength index	0.408	Control group left side change direction deficit	0.106
Experimental Group Right Side reactive strength Index	0.095	Experimental group right change of direction deficit	0.109
Control group right side reactive strength index	0.744	Control group right side change to deficit	0.587

Note: A Shapiro-Wilk test result >0.05 indicates that the test scores conform to a normal distribution.

Table 10. Results of leg muscle strength and sensitivity tests in the two pre-test groups

Test items	Experimental group pre-test	Experimental group posttest	P-value
Left Countermovement Jump(cm)	21.63±3.48	23.47±4.96	0.964
Right Countermovement Jump(cm)	21.84±3.36	22.67±4.67	0.939
Bilateral Reverse Jump(cm)	41.19±4.12	40.52±6.58	0.495
Left reactive strength index(m/s)	0.58±0.03	0.60±0.12	0.589
Right reactive strength index (m/s)	0.58±0.1	0.59±0.13	0.512
Bilateral reactive strength index (m/s)	0.90±0.23	0.90±0.27	0.753
Lower body asymmetry index	7.52±3.92	6.17±4.85	0.736
Left lateral change of direction deficit(s)	0.79±0.07	0.78±0.09	0.780
Right side change of direction deficit(s)	0.77±0.10	0.73±0.09	0.073
V-cut	6.94±0.43	6.88±0.37	0.879

Note: P>0.05 indicates no significant difference in pretest scores.

As can be seen from Table 9, the Shapiro-Wilk test results of leg explosive strength and sensitivity pre-test scores of the experimental and control groups are greater than 0.05, indicating that many test scores of the two groups are in line with normal distribution. As shown in Table 10, the independent samples t-test results of many pre-test scores of the two groups are greater than 0.05, indicating that there is no significant difference between the experimental group and control group in the pre-test scores of leg explosive strength and sensitivity. The above test results meet the conditions for the next step of analysis.

5.2 Results of leg explosive strength test in the group before and after experimentation

Table 11. Results of leg explosive strength tests in the group before and after the experiment

Explosive strength of the legs Test items	Experimental group			Control group		
	Pre-test	Post-test	P-value	Pre-test	Post-test	P-value
Left Countermovement Jump(cm)	21.63±3.48	25.21±4.16*	0.014	23.47±4.96	23.89±4.95	0.308
Right Countermovement Jump(cm)	21.84±3.36	24.67±3.62*	0.038	22.67±4.67	23.58±4.87	0.077
Bilateral Countermovement Jump (cm)	41.19±4.12	43.75±4.75**	0.007	40.52±6.58	44.87± 6.05**	<0.001
Left reactive strength index (m/s)	0.58±0.03	0.63±0.12*	0.048	0.60±0.12	0.58±0.14	0.604
Right reactive strength index (m/s)	0.58±0.1	0.64±0.15*	0.017	0.59±0.13	0.58±0.17	0.879
Bilateral reactive strength index (m/s)	0.90±0.23	1.32±0.19**	<0.001	0.90±0.27	1.22±0.38*	0.012
Lower body asymmetry index	7.52±3.92	6.17±3.04	0.531	6.17±4.85	7.33±3.78	0.435

Note: * indicates P < 0.05 and ** indicates P < 0.01 compared to preexperiment (*superscript)

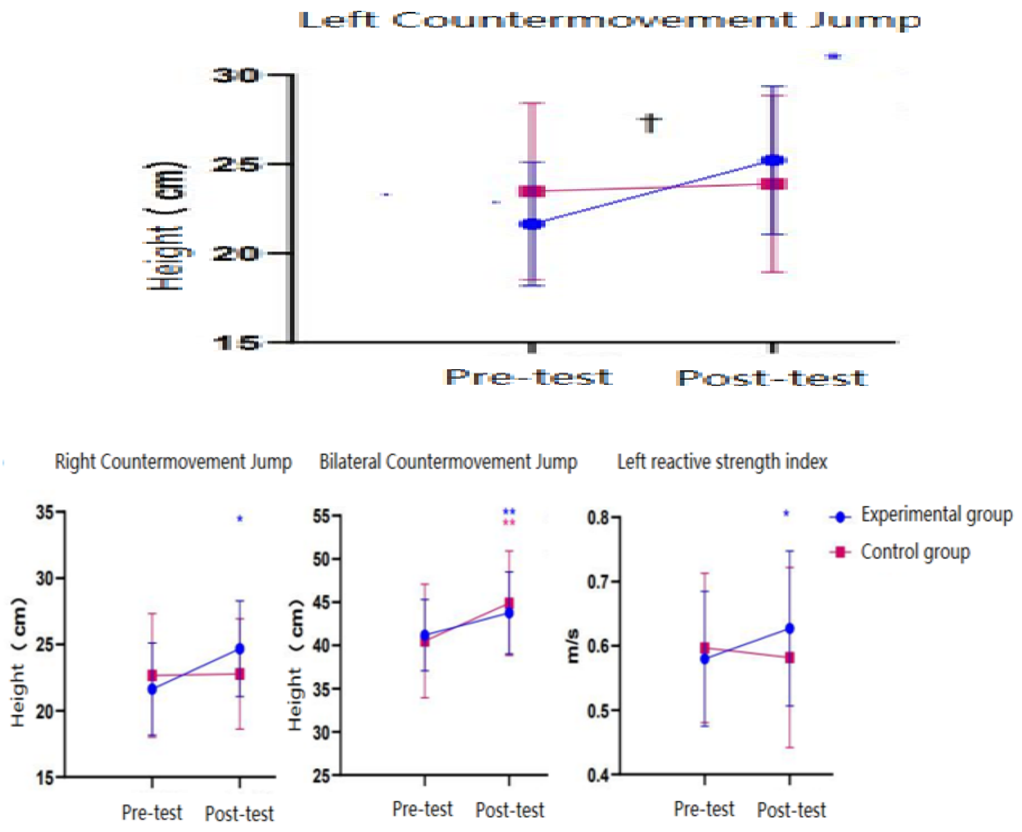

Figure 6. Effect of unilateral and bilateral super isometric training of the lower body on leg explosive power

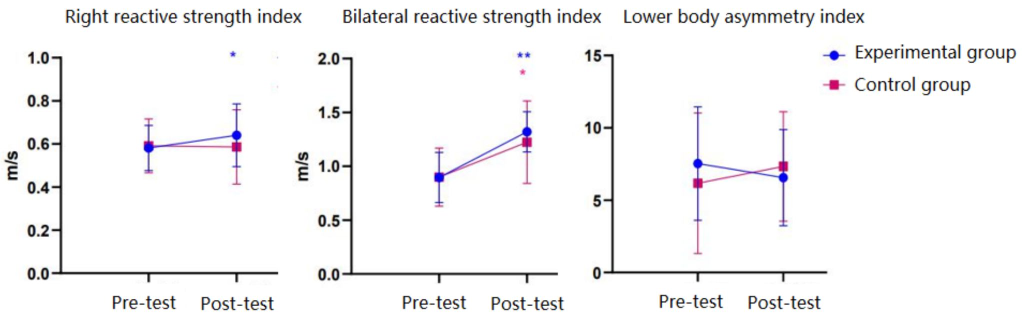

Figure 7. Effect of unilateral and bilateral super isometric training of the lower body on leg explosive strength

Note: † indicates a significant time × group interaction, $P<0.05$: * indicates $P<0.05$ compared to preexperiment, ** indicates $P<0.01$ compared to preexperiment (*superscript).

The results of explosive strength test of the experimental group can be seen in Table 11, Figure 6 and Figure 7: There was a significant difference ($P<0.05$) between the experimental group before and after the intervention in the test scores of left reverse jump ($P=0.014$), right reverse jump ($P=0.038$), bilateral reverse jump ($P=0.007$), left reaction strength index ($P=0.048$), right reaction strength index ($P=0.017$), and bilateral reaction strength index ($P<0.001$).

However, there was no significant difference in the lower limb asymmetry index test scores (P<0.05). The above results indicated that the experimental group significantly improved the left reverse jump, right reverse jump, bilateral reverse jump, left side reaction strength index, right side reaction strength index, and bilateral reaction strength index, however, failed to significantly improve the lower limb asymmetry index.

Control group explosive strength test results: There was a significant difference (P<0.05) between the control group before and after the intervention in the test scores of bilateral reverse jump (P<0.001) and bilateral reaction power index (P=0.012). However, there was no significant difference (P>0.05) in the test scores of left reverse jump (P=0.308), right reverse jump (P=0.077), left reaction strength index (P=0.604), right reaction strength index (P=0.879), and lower limb asymmetry index (P=0.435).

The above results showed that the control group significantly improved bilateral reverse jump and bilateral reaction strength index, however, failed to significantly improve left reverse jump, right reverse jump, left reaction strength index, right reaction strength index and lower limb asymmetry index.

5.3 Comparison of Leg Explosive Strength Test Results Between Posttest Groups

Table 12. Results of Leg Explosive Strength Tests Between Post-test Groups

Leg Explosive Strength Test Item	Control group posttest	Experimental group posttest	P-value	Bias η2
Left Countermovement Jump(cm)	23.89±4.95	25.21±4.16#	0.021	0.263
Right Countermovement Jump(cm)	23.58±4.87	24.67±3.62	0.143	0.116
Bilateral Countermovement Jump(cm)	44.87±6.05	43.75±4.75	0.104	0.140
Left reactive strength index(m/s)	0.58±0.14	0.63±0.12	0.091	0.151
Right reactive strength index (m/s)	0.58±0.17	0.64±0.15	0.063	0.179
Bilateral reactive strength index (m/s)	1.22±0.38	1.32±0.19	0.453	0.032
Lower body asymmetry index	7.33±3.78	6.17±3.04	0.428	0.035

Note: † indicates a significant time × group interaction, $P < 0.05$. # indicates $P < 0.05$ compared with control (# superscript).

As can be seen in Table 12 and Figure 8, the results of the post-experimental measurement of leg explosive power between the experimental and control groups showed that: the two groups interacted significantly (p<0.05) only in the left side reverse jump (F=3.20, p=0.021, bias η2=263). However, the two groups jumped in right side reverse (F=2.632, P=0.143, partial η2=0.116), bilateral reverse jump (F=0.712, P=0.104, partial η2=0.956), the left side reaction force index (F=0.268, P=0.091, biased η2=0.151), right side response strength index (F=0.271, p=0.063, biased η2=0.179), bilateral reaction strength index (F=1.271, p=0.453, bias η2=0.032) and lower limb asymmetry index (F=4.301, P=0.428, partial η2=0.035) failed to produce a significant interaction (P>0.05). The difference between the experimental group and the control group was significantly different only in the left side reverse jump, which was significantly improved compared to the control group, except for that, there was no significant difference between the two groups in the performance of other explosive strength indexes.

5.4 Results of within-group sensitivity tests before and after experimentation

Table 13. Results of within-group sensitivity tests before and after experimentation

Sensitivity Test Items	Experimental group			Control group		
	Pre-test	Post-test	P-value	Pre-test	Post-test	P-value
Left side change of direction deficit(s)	0.79±0.07	0.68±0.08**	0.005	0.78±0.09	0.74±0.08*	0.034
Right side change of direction deficit(s)	0.77±0.10	0.65±0.06**	0.008	0.73±0.09	0.71±0.09	0.348
V-cut(s)	6.94±0.43	6.51±0.31**	<0.001	6.88±0.37	6.70±0.28*	0.043

Note: * indicates P < 0.05 and ** indicates P < 0.01 compared to preexperiment (*superscript).

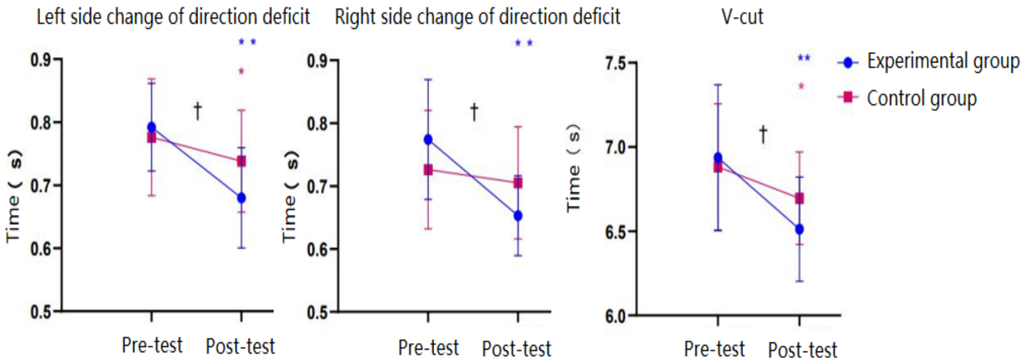

Figure 8. Effect of unilateral and bilateral super isometric training of the lower body on sensitivity

Note: † indicates a significant time × group interaction, P<0.05: * indicates P<0.05 compared to preexperiment, ** indicates P<0.01 compared to preexperiment (*superscript).

As shown in Table 12 and Figure 8, the results of the sensitivity test of the experimental group: the difference between the experimental group before and after the intervention in the test scores of the left side change of direction deficit (P=0.005), the right side change of direction deficit (P=0.008), and the V-cut (P<0.001) was very significant (P<0.01). The above results indicate that the experimental group significantly improved the left side change deficit, right side change deficit, and V-cut. Sensitivity test results of the control group: there was a significant difference in the test scores of the control group before and after the intervention in the left side change of direction deficit (P=0.034) and V-cut (P=0.043) (P<0.05), and there was no significant difference in the test scores of the control group in the right side change of direction deficit (P=0.348) (P>0.05). The above results indicated that the control group significantly improved the left side change of direction deficit, V-cut, and failed to significantly improve the right side change of direction deficit.

5.5 Comparison of sensitivity test results between posttest groups

Table 14. Post-experimental sensitivity test results between groups

Sensitivity Test Items	**Control group posttest**	**Experimental group posttest**	**P-value**	**Bias η2**
Left side change of direction deficit(s)	0.74±0.08	0.68±0.08$^{\#}$	0.044	0.213
Right side change of direction deficit(s)	0.71±0.09	0.65±0.06$^{\#}$	0.027	0.245
V-cut(s)	6.70±0.28	6.51±0.31$^{\#}$	0.030	0.236

Note: † indicates a significant time × group interaction, P<0.05: # indicates P<0.05 compared to preexperiment, and ## indicates P<0.01 compared to preexperiment (# superscript).

As shown in Table 14 and Figure 8, the results of the post-experimental measurement of the sensitivity of the experimental group and the control group showed that the two groups significantly (P<0.05) improved the left side variable deficit (F=1.762, P=0.044, biased η2=0.213), the right side variable deficit (F=1.230, P=0.15, biased η2=0.245) and V-cut (F=0.46, P=0.03, bias η2=0.236) interacted significantly (P<0.05), with the experimental group significantly improving left-side variance deficit, right-side variance deficit, and V-cut compared to the control group.

5.6 Analysis of results

5.6.1 Effect of different types of strength training on explosive strength

(1) Effects of unilateral super isometric training on leg explosive strength

Super isometric training has been shown to improve lower extremity stiffness. The concept of stiffness is defined as the ratio of external load to the amplitude of deformation of human tissues, and the coordination and interaction of human tissues determine the level of stiffness, which is closely related to athletic performance. The lower limb can improve the reuse rate of elastic potential energy by improving the level of stiffness, and reduce the loss of elastic potential energy in the transition from centrifugal to centripetal contraction. Hyper-equal length training in unstable state can enhance the centripetal contraction strength of the lower limb, improve intermuscular coordination, and enhance trunk stability, which can promote the development of explosive force. In this study, unilateral super isometric training requires the lower limb to complete not only stomping and jumping movements in multiple directions, but also multi-directional single-leg landing support movements, which requires high neuromuscular control ability, and unilateral support leg jump and landing jump-stop movements can effectively activate the deep trunk muscles, maintain body posture, improve the transmission efficiency of the power chain, and improve balance and proprioception.

(2) Effects of bilateral super isometric training on leg explosive strength

Super isometric training improves the neuromuscular system by increasing the number of motor units recruited, the frequency of nerve impulse delivery and synergy, and enhances neuromuscular control by improving nerve-dominated centripetal contraction. The SSC, the stretch reflex, and the neurologically-dominated centripetal contraction mechanism are important factors influencing the level of explosive force output. Reverse movements utilizing the SSC can improve performance by at least 10-15% compared to non-reverse movements, and the SSC is an integral component in the execution of explosive movements. In SSC, elastic potential energy is stored in the muscle and tendon tissues, and the tendon, as the main component of the tandem elastic tissue, mainly releases the elastic potential energy stored in the centrifugal contraction, and the centrifugal and centripetal transition time greatly affects the utilization rate of the elastic potential energy, and a longer transition time (>0.25s) will result in the failure of the elastic potential energy to be released in a timely manner. SSC can be categorized into fast SSC and slow SSC based on 0.25s. For example, the centrifugal-to-centripetal transition time of SSC in the reverse jump is usually greater than 0.25s, and the transition time of SSC in the deep jump is usually less than 0.25s. In this study, the intervention content was based on the muscle contraction characteristics, and the exercise contents of less than and more than 0.25s SSC were developed respectively. The fast SSC training exercises included jumping to the depth and jumping to the rail, and the slow SSC exercises included jumping in reverse and frog jumping, so as to comprehensively develop the fast SSC and the slow SSC.

(3) Differential effects of unilateral and bilateral super isometric training on leg explosive strength

Unilateral training induces cross-migration between the cerebral cortex and the spinal cord, and muscle contraction on one limb not only increases muscle strength on the training side, but also enhances the strength of homologous muscles on the non-training side. When the form of muscle contraction in the intervention cycle is the same as that in the plyometric test, it can cause more obvious cross-migration present effects, for example, after super-equalization of the training side, it causes the contralateral homologous muscles to produce the best super-equalization intervention effect. However, compared with unilateral muscle group contraction, simultaneous contraction performed by both muscle groups may reduce the muscle contraction force of one limb, and the effect of bilateral training on improving unilateral muscle strength is not as obvious as that of unilateral training, which can activate the motor units of the non-force side and improve the strength of the muscle groups of the non-force side in the case of one limb force, leading to the enhancement of the muscle strength of the non-force side.

Unilateral support of the lower limbs is closer to the unstable state, and compared with the stable state, super-equal length training in the unstable state is more helpful to the development of proprioception, improve intermuscular coordination, and enhance trunk stability, which can effectively promote the development of explosive strength of the lower limbs. In this study, unilateral and bilateral super-equal length training content integrated multi-directional jumping and jump-stopping movements, and compared with bilateral super-equal length training content, unilateral super-equal length training content under unstable state was more able to enhance the strength of the deep trunk muscles and body posture control ability, and improve the conduction efficiency of the power chain.

5.6.2 Effect of different types of strength training on sensitivity

(1) Effects of unilateral super isometric training on sensitivity

Unilateral jumps and jump-stops require a high degree of control of the neuromuscular system, and single-leg jumps and jump-stops not only help to improve the synergy between muscle groups and enhance the core trunk control ability, but also reduce the contradiction between change-of-direction performance and higher approach velocities. Compared with lower approach speeds, if the braking buffer is performed at higher approach speeds, the load on the knee joint is usually greater than that at lower approach speeds, and the higher the approach speed, the higher the potential risk of injury. Enhancing muscle strength, postural control and balance can reduce the contradiction between the change of direction performance and sports injuries, and achieve the training goal of improving sensitivity.

(2) Effect of bilateral super-equal length training on sensitivity

On the one hand, the directional variables in the exercise content can have a differential effect on the neuromuscular adaptation effect, and there is a certain degree of mechanical demand in the vertical and horizontal directions during the change-of-direction maneuver, and the bilateral training content of this study involves the vertical and horizontal directions, which enhances the propulsion and braking forces of the lower limbs in the vertical and horizontal directions.

On the other hand, the form of muscle contraction can differentially affect the training effect, proving the importance of centrifugal force of the leg for sensitivity. In order to effectively develop the centrifugal buffering, support transition and re-acceleration processes during the change of direction, the first phase of training focused on improving the landing and stopping movements of the legs and body posture control, developing the centrifugal braking ability during the change of direction, and improving the ability of the lower limbs to withstand the impact of the ground.

The second phase of training increases the stretching load on the muscles and connective tissues by increasing the small bounces before the maximal effort jumps, in order to shorten the transition time of the change of direction and lay the foundation of muscle strength.

The third phase of training is based on the intensity of the previous movements and strength, and requires the completion of maximum jumps in the shortest possible time to touch the ground, which corresponds to the development of the re-acceleration ability of the change of direction process.

(3) Differential effects of unilateral and bilateral super isometric training on sensitivity

Unilateral training has an advantage that cannot be compared with bilateral training, that is, unilateral training can be closer to the mechanical characteristics of the change of direction movement on the field of play, and cause more effective migration effects. The process of change of direction can be divided into braking and deceleration, support conversion and re-acceleration phase, which requires athletes to maintain a better body posture, rely on a single leg to control the body in the vertical and horizontal direction for braking and re-acceleration. Given that the content of super-equal length training involves centrifugal and centripetal contraction transition mechanism (SSC), unilateral super-equal length training is undoubtedly more in line with the requirements of specialized mechanics and muscle contraction forms than bilateral super-equal length training content.

Approach velocity before cutting is a key factor affecting sensitivity, and accomplishing braking deceleration at higher approach velocities puts high demands on the centrifugal force of the single leg. Compared with the two-legged jump-stop maneuver, the centrifugal load borne by the single leg in the jump-stop maneuver in the unilateral super-equal length training content is greater than that in the two-legged jump-stop maneuver, so the unilateral super-equal length training helps to improve the centrifugal strength of the single leg, enhance the ability of the lower limb to withstand the impact force on the ground, and enhance its ability to rapidly reduce speed in high-speed movement. The support transition phase during the change-of-direction maneuver is a prerequisite for completing the body cut into the target direction; however, unilateral and bilateral super-equal-length training may differentially affect the stability of the lower limb joints. In this study, the unilateral group and bilateral group performed single and double leg jumps and landing jump-stop movements respectively, focusing on the development of the jump-stop movement, which requires athletes to jump with maximum effort and then quickly lower the center of gravity through active hip flexion to maintain the single leg and double leg landing jump-stop postures respectively. Compared with the bilateral super-equal length training, the unilateral support leg jumping and stopping action is more helpful to enhance the stability of the lower limbs on the ground, activate the deep trunk muscles, improve the efficiency of the power chain transfer, consider the change of direction process by the single leg to complete the support conversion process, the unilateral super-equal length training is more helpful to improve the stability of the single-leg support to reduce the conversion phase of the touchdown time, the mechanical advantages of this is the bilaterally super-equal length training does not have. This mechanical advantage is not present in bilateral hyperextension training. In addition, compared with bilateral super-equal length training, the content of unilateral super-equal length training is closer to the unstable state, and unilateral super-equal length training is more capable of improving the body postural control and proprioception than bilateral super-equal length training , and is more helpful to improve the ability of transferring the body center of gravity to the target direction during the change of direction.

6. Conclusion

(1) Both unilateral and bilateral super-equalization training methods were able to have a positive effect on the explosive strength of the legs of basketball players; secondly, unilateral super-equalization training was significantly more effective than bilateral super-equalization training in terms of sensitivity and lowering the level of lower limb asymmetry.

(2) Compared with bilateral super-equal length training, unilateral super-equal length training is more in line with the mechanical characteristics of the change of direction movement and the form of muscle contraction, and it is more important for the improvement of leg muscle strength and the number of change of direction indexes than bilateral super-equal length training. As a result, unilateral isometric training can have a more positive effect on the nerves of the leg muscles.

(3) In view of the characteristics of the basketball sports program, the unilateral power of the leg on the court in the form of action to use more, such as high-intensity rapid speed change, change of direction, folding and other technical actions. Therefore, in the usual training, it is recommended that coaches use more unilateral super-equal length training.

(4) Since both unilateral and bilateral super-equalization training can have a positive effect on improving leg explosive strength and sensitivity, coaches can use both types of training. Therefore, in the training of explosive strength and sensitivity of the legs, coaches can use these two kinds of training. Based on the large intensity load of super-equal length training, the training process must follow the principle of gradual increase in training intensity. Bilateral super-equal length training can be carried out first, and when there is a certain strength base, unilateral super-equal length training can be carried out, so as to avoid injury.

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