The Increased Effectiveness of Loaded Versus Unloaded Plyometric-Jump Training in Improving Muscle Power, Speed, Change-of-Direction, and Kicking-Distance Performance in Prepubertal Male Soccer Players

ABSTRACT

Purpose: This study examined the effects of loaded (LPJT) and unloaded (UPJT) plyometric jump training programmes on measures of muscle power, speed, change-of-direction and kicking-distance performance in prepubertal male soccer players. **Methods:** Participants (*N*=29) were randomly assigned to a LPJT group (n=13; age=13.0±0.7 years) using weighted vests or UPJT group (n=16; age=13.0±0.5 years) using body mass only. Before and after the intervention, tests for the assessment of proxies of muscle power (i.e., countermovement-jump [CMJ], standing-long-jump [SLJ]), speed (i.e., 5-m, 10-m, and 20-m sprint), change-of-direction (i.e., Illinois change-of-direction test [ICoDT], modified 505 agility test), and kicking-distance test were conducted. Data were analysed using magnitude-based inferences. **Results:** Within-group analyses for the LPJT group showed large and very large improvements for 10-m sprint-time (effect size [ES]=2.00) and modified 505 CoD (ES=2.83) tests, respectively. For the same group, moderate improvements were observed in ICoDT (ES=0.61), 5- and 20-m sprint-time (ES=1.00 for both tests), CMJ (ES=1.00) and MKD (ES=0.90). Small enhancements in the SLJ (ES=0.50) test were apparent. Regarding the UPJT group, small improvements were observed for all tests (ES=0.33 to 0.57) except 5-m and 10-m sprint-time (ES=1.00 and 0.63, respectively). Between-group analyses favored the LPJT group for the modified 505 CoD (ES=0.61), SLJ (ES=0.50), and MKD (ES=0.57) tests, but not for 5-m sprint-time (ES=1.00). Only trivial between-group differences were shown for the remaining tests (ES=0.00 to 0.09). **Conclusion:** Overall, LPJT appears to be more effective than UPJT in improving measures of muscle power, speed, change-of-direction and kicking-distance performance in prepubertal male soccer players.

Key words: young, football, stretch-shortening cycle, maturity, athletic performance

INTRODUCTION

In elite soccer players, both young and old, physical qualities such as sprinting, jumping, and change of direction (CoD) speed are major determinants of performance. [1] Indeed, previous studies have demonstrated that elite soccer players are characterized by high levels of muscular strength, speed and derivatives thereof (i.e., acceleration, sprinting, jumping, and CoD), when compared to sub-elite soccer players.[2,3] Accordingly, the development of muscle power, speed and CoD through well-designed strength and conditioning programs is vital to optimise the development of the elite soccer player.

Previous studies have shown that unloaded plyometric jump training (UPJT), during which the performer must propel their own body mass, is an easy-to-administer, safe, effective, and efficient training method to improve physical fitness during different stages of maturation and long-term athlete development.[2] Generally, UPJT involves various forms of hopping and jumping exercises in vertical and horizontal directions, on stable and unstable surfaces. The magnitude of training effects following UPJT depends on the manipulation of different training modalities such as the training surface, [1,3] intensity (e.g., drop-height), [4] frequency, [5] direction (e.g., horizontal, vertical), [6] the number of involved limbs (i.e., unilateral, bilateral jumping), [7] and sequencing effect (e.g., UPJT before or after the training session). [8]

From a physiological perspective, plyometric jump training (PJT) exercises involve the use of the stretch-shortening cycle (SSC) which is characterised by an eccentric muscle action that is immediately followed by a concentric muscle action. [9] The immediate succession of an eccentric muscle action, such as the descent phase of a jump, with a concentric action, such as the take-off phase, results in stimulation of a stretch reflex, potentiating performance during the propulsive phase of jumping [10]. This stretch reflex can be modulated by the velocity of the stretch [10,11] and the magnitude of the stretching load. [12,13] Due to this, a potential way to enhance adaptations to PJT is to use extra-loads additional to body mass (LPJT). [14-16]

In this context, Rosas et al. [16] compared the effects of a 6-week LPJT programme, using handheld dumbbells, with UPJT on jump performances and maximal ball kicking-velocity in young male soccer players (aged 12 years). These authors reported small performance improvements in countermovement jump (CMJ), horizontal jumps, reactive strength index and maximal kicking-velocity (effect size [ES]=0.27 to 0.47), with larger effects seen in LPJT than in UPJT. Additional loads may have induced larger stretch reflex amplitudes during training and this could have translated to larger performance gains following LPJT. [12,13,17] Importantly, Rosas et al. [16] did not record any training-related injuries and clearly concluded that LPJT is a safe and effective training approach for the studied population. However, these authors [16] did not include any measure of CoD or sprinting speed performance, thus limiting the applicability of the results to an important determinant of soccer performance in youth.[18]

Further to the above, Kobal et al. [15] compared the effects of 6 weeks of LPJT, using handheld dumbbells, and UPJT on measures of muscle power and speed in elite young male soccer players (aged 16 years), reporting better improvements in vertical jumping performance in LPJT group (Δ9.4% and 8.4% for squat jump [SJ] and CMJ, respectively, in LPJT group; Δ4.6% and 5% for the SJ and CMJ in UPJT group, respectively). Recently, Coratella et al. [14] studied the effects of 8 weeks of LPJT or UPJT in recreationally trained male soccer players (aged 21 years). These authors found that CoD and sprint performances improved to a larger extent in the LPJT group (ES=2.95, 0.52, and 0.52 for T-test, 10-m and 30-m sprint tests, respectively) compared to the UPJT group (ES= 0.04, 0.10, and 0.06 for T-test, 10-m and 30-m sprint tests, respectively). In contrast, larger increases in jump performances were found following UPJT (ES=0.89, and 0.55 for the SJ and CMJ test, respectively).

Given inconsistent findings in the literature on the effects of LPJT when compared to UPJT [15-17], as well as considerable heterogeneity across study characteristics and outcome measures (i.e., sample size, training modalities, age categories), further research is needed. Accordingly, we sought to examine the effects of LPJT and UPJT on a wider range of important performance determinants (i.e., vertical and horizontal jump performance, linear sprint-time, CoD, and kicking distance) in youth soccer players. The optimal PJT strategy that may elicit the largest physical fitness improvements in this population is still under debate. With reference to previous research [12,14,16], we hypothesised that LPJT would induce larger improvements on measures of muscle power, speed, CoD and kicking-distance performance than UPJT in prepubertal male soccer players.

METHODS

Participants

Twenty-nine healthy young male athletes from a regional soccer academy were randomly assigned either to a LPJT group (n=13) using additional weighted vests with a load of 8% of the body mass during exercise [15]; or an UPJT group (n=16) which used no additional load during training. All participants were classified as experienced players with 5.0 ± 1.3 years of systematic soccer training background comprising of 3 to 5 training sessions per week. Anthropometric data of both groups are presented in Table 1. Participants who missed more than 20% of the total number of training sessions and/or more than two consecutive sessions, were excluded from the study. [3] Participants' maturation status was determined according to the offset method. [19] All procedures were approved by the local ethics committee for the use of human participants in accordance with the latest version of the Declaration of Helsinki. Written informed parental consent and participants' assent were obtained prior to the start of the study. All participants and their parents/legal representatives were fully informed of the experimental protocol, and its potential risks and benefits, prior to its commencement.

Experimental design

A parallel two-group repeated measures experimental design was conducted to examine the effectiveness of LPJT and UPJT on measures of muscle power, speed, CoD and kicking-distance performance in prepubertal male soccer players. Both training interventions were conducted during the in-season period. Two weeks before baseline testing, two sessions were performed to familiarise participants with the applied fitness tests. Of note, participants were used to the applied PJT drills and had achieved good technical competency, through training activities, before starting the study. Before and after training, tests for the assessment of proxies of muscle power (i.e., countermovement-jump [CMJ], standing-long-jump [SLJ]), speed (i.e., 5-m, 10-m, and 20-m sprint test), CoD (i.e., Illinois change-of-direction test [ICoDT], modified 505 agility test), and kicking-distance test were conducted. All tests were scheduled at least 48 hours after players' most recent training session or competition. The warm-up protocol preceding testing included 5 minutes of submaximal running with CoD exercises, 10 minutes of submaximal plyometrics {20 verticals (i.e., CMJs) and 10 horizontal jumps (i.e., bilateral ankle hops)}, dynamic stretching exercises, and 5 minutes of a sprint-specific warm-up.

Table 1 near here

Illinois change of direction test

The ICoDT was conducted as previously outlined by Negra et al.[3] The time needed to complete the test was used as a performance outcome and it was assessed using a single beam infrared photocell device (Microgate SRL, Bolzano, Italy). Each participant performed three trials with a 3-min rest between each. The best trial was used for further analysis. The ICC for test-retest trials was 0.94.

The modified 505 change of direction test

During a modified 505 agility test, athletes were instructed to perform a 5-m sprint from a starting line, to place the preferred foot on the 5-m line, turn 180° and sprint back 5-m through the start/finish line. Single beam infrared photocell gates (Microgate SRL, Bolzano, Italy) were placed at the start line 0.75-m above the ground. A resting between-trial period of 3-min was provided. The best performance out of three trials was used for further analysis. The ICC for test-retest trials was 0.94.

Sprint-time

The performance of a 20-m linear sprint was recorded using an infrared photocell system (Microgate, Bolzano, Italy). Additionally, split sprint times of 5-m and 10-m were analysed. In total, four single beam photoelectric gates were used. The between-trial recovery time was 3-min. The best performance out of three trials was used for further analysis. The ICCs for test-retest reliability were 0.92, 0.94, and 0.97 for 5-m, 10-m, and 20-m, respectively.

Countermovement jump

During the CMJ, participants started from an upright erect standing position and performed a fast downward movement by flexing the knees and hips before rapidly extending the legs and performing a maximal vertical jump. During the test, participants were instructed to maintain their arms akimbo. Jump height was recorded using an optoelectric system (Optojump, Microgate, SRL, Bolzano, Italy). A rest period of 1-min was allowed between trials. The best out of three trials was retained for further analysis. The ICC for test-retest reliability was 0.96.

Standing-long-jump

During the SLJ test, participants stood with their feet shoulder-width apart and in front of a starting line. On the command of "ready, set, go", participants performed a fast flexion of the legs and downward movement of the arms, before jumping as far as possible in a horizontal direction. Participants had to land with both feet at the same time and were not allowed to fall forward or backward. The horizontal distance between the starting line and the heel of the rear foot was recorded using a tape measure to the nearest 1-cm. A between-trial rest period of 1-min was allowed. The best out of three trials was recorded for further analysis. The ICC for test-retest reliability was 0.97.

Maximal kicking distance test

The maximal kicking distance test (MKD) was conducted as previously outlined by Bouguezzi et al. [20] The maximal distance attained by the ball was measured using a metric tape. An evaluator was placed near to the region where the ball landed to accurately locate the point of contact and to measure the distance of the kick to the nearest 0.2-m. The wind velocity was <20 km.h^{-1} during all the testing sessions (local Meteorological Service). A between-trial rest period of 1-min was provided. The best out of three trials was recorded for further analysis. The ICC for test-retest trials was 0.95.

Plyometric jump training

The two experimental groups participated in an 8-week in-season PJT program consisting of two training sessions per week. Overall, the UPJT and LPJT groups conducted five regular soccer training sessions per week. The PJT was integrated into the regular training routine of the soccer team, replacing some soccer-specific drills. The inter-day rest interval between plyometric training sessions was at least 72 h. A standardised warm-up of 8 to 12-min duration was completed. It included low intensity running, coordination exercises, dynamic movements, sprints, and dynamic stretching for the lower limb muscles prior to each PJT session. Soccer training sessions lasted between 80 and 90-min. The LPJT and UPJT drills lasted between 20 and 25-min. The remaining training time was dedicated to technical and tactical drills. The first training session was performed at least 48 hours after the soccer match that was scheduled on the weekend. The LPJT and UPJT protocols were based on that of a previously published study [21]. Details of the respective protocols are illustrated in Table 2. The PJT (i.e., LPJT, UPJT) included vertical (i.e., CMJs) and horizontal (i.e., bilateral forward ankle hops) jumps performed at maximal effort (i.e., maximal height and forward distance with a minimal contact time for vertical and horizontal jumping, respectively). Both groups performed cyclic jumps using an arm-swing. According to previous studies, [8,22] training volume was progressively increased throughout the 8-week intervention period. While participants of the UPJT group performed all jump exercises using no additional loads, participants in the LPJT group executed the same exercises using weighted vests (8% participants' body mass)[15]. Both sessions consisted of a volume of 4-6 sets and 6-10 repetitions. The total number of ground contacts per session was 50 during the first week and gradually increased to 120 after eight weeks of training. A 90-s rest was provided between each set of each exercise. The jump training protocols were supervised by a qualified instructor.

Table 2 near here

STATISTICAL ANALYSES

Statistical analyses included calculation and interpretation of effect sizes using magnitude-based inferences. The following outlined ranges were used to interpret effect size: <0.2 = trivial; 0.2–0.6 = small, 0.6–1.2 = moderate, 1.2–2.0 = large, 2.0–4.0 = very large, >4.0 = extremely large. [22] An effect size of 0.2 was considered to be the "smallest worthwhile change". [22] The estimates were considered unclear when the chance of a beneficial effect was high enough to justify the use of the intervention (>25%), yet the risk of being harmful was unacceptable (>0.5%).[22] An odds ratio of benefit to harmful of □60 was indicative of such unclear effects.[23] This was calculated using an available spreadsheet.[23] The scale used to interpret the probabilities was as follows: possible = 25–75%; likely = 75–95%; very likely = 95–99.5%; most likely >99.5%.[22,23] Uncertainty in the effect sizes was represented by 90% confidence limits. Effects were considered unclear if the confidence interval crossed thresholds for substantial positive and negative values. Otherwise, the effect was clear and reported as the magnitude of the observed value with a qualitative probability.[22] Test-retest reliability was assessed using the intraclass correlation coefficients (ICCs).

RESULTS

All subjects received treatment conditions as allocated. Three participants from the LPJT group withdrew from attending the youth soccer training center for personal reasons and were, therefore, excluded from the study. The training compliance rate was 95% for the two groups. Table 3 displays test data for all components of physical fitness assessed at baseline and follow-up. There were no statistically significant baseline differences between the groups in chronological age, body height, body mass, APHV or soccer experience (Table 1). Additionally, no between-group differences were recorded at baseline for any test of physical fitness (Table 3).

Within-group analyses for the UPJT group showed small positive effect sizes for the ICoD, modified 505 CoD, 20-m sprint-time, CMJ, SLJ, and MKD tests (Table 3). In the same group, moderate performance improvements were shown for the 5-m and 10-m sprint-time tests. Regarding the LPJT group, large and very large effect sizes were shown for the 10-m sprint-time and modified 505 CoD tests, respectively. For the ICoD, 5- and 20-m sprint-time, CMJ, and MKD, moderate positive effect sizes were recorded. The performance improvement for the SLJ test was small. Outcomes of the between-group analyses favored the LPJT group for the modified 505 CoD, SLJ, and MKD tests with small to moderate effect sizes (Table 4). However, there were greater performance improvements in the 5-m sprint for the UPJT group. For the remaining tests (ICoD, 10-m, 20-m, and CMJ), trivial between-group differences were demonstrated (Table 4).

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DISCUSSION

The aim of this study was to compare the effects of 8 weeks of LPJT or UPJT program on measures of muscle power, speed, CoD and kicking-distance performance in prepubertal male soccer players. The main finding of the study was that LPJT induced larger performance improvements compared to UPJT on measures of muscle power, speed, CoD and kicking-distance performance in prepubertal male soccer players.

Change of direction

Mirkov et al.[24] reported that CoD performance is a key determinant of high performance play in the sport of soccer. Our results showed small improvements in the ICoD and 505 CoD tests after UPJT whilst moderate and very large performance improvements were seen in the ICoD and 505 CoD tests, respectively, after LPJT. The CoD performance improvements following UPJT were expected considering the extensive empirical studies supporting the effectiveness of this type of training in youth populations. [21,25,26] Recently, Coratella et al.[14] studied the effects of 8 weeks of loaded (1.2 x body-mass) or unloaded (body mass only) jump-squat training in recreationally trained male soccer players (aged 21 years). These researchers found that the loaded jump-squat group improved T-test performance (ES=2.95) whilst no changes occurred following the unloaded programme (ES=-0.04). The authors attributed the greater CoD improvements to the increased braking ability generated by the enhanced eccentric workload associated with loaded training. Sheppard and Young, [27] suggest that PJT can improve eccentric strength of the thigh muscles, an important determinant of performance during the deceleration phase of CoD movements.[28] Improvements in CoD performance following PJT could occur due to the interaction of several training-related neuromuscular adaptations including the improvement of neural drive to agonist muscles, patterns that enable athletes to rapidly switch between deceleration and acceleration motions (i.e., higher efficiency of the stretch-shortening cycle), and muscle activation strategies (i.e., inter- and intra-muscular coordination).[29,30] In particular, better CoD performance following LPJT, compared to UPJT, seems to be due to the potentiation of a greater stretch-reflex because of additional loading during PJT. [12,13] Additionally, as eccentric strength is an important determinant of deceleration ability during CoD movements, [28] the higher inertia accumulated during the braking phase during LPJT may have contributed to an increases in eccentric workload and, therefore, larger strength improvements.[14] However, further studies including kinetic/kinematic and/or physiological tests have to be conducted to confirm the current findings.

Speed performance

Sprinting activities are frequently performed prior to decisive situations in soccer matches such as goal scoring. [32] The findings of the present study showed small to moderate improvements in sprint performance in the UPJT group and moderate to large improvements in the LPJT group. These results corroborate those of Coratella et al.[14] who studied the effects of 8 weeks of loaded (30% of squat 1RM) and unloaded jump-squat training in recreationally trained male soccer players (aged 21 years). These researchers reported improvements in sprint performance over 10-m and 30-m in the loaded squat-jump group only (ES=0.52 for both 10 and 30-m), attributing this finding to the greater eccentric load imposed by the LPJT programme. Improvements in the sprint performance of prepubertal male soccer players are well-established in the literature. [1,4,20] Indeed, the results of the present study demonstrated larger effects on sprinting speed after LPJT than after UPJT. Of note, sprinting speed improvements occur primarily due to neural-orientated factors and the development of the central nervous system during the prepubertal phase of development. [2,18] However, such changes are more likely to occur over the longer term. Within the short timescale of the current study, enhancement of the stretch-reflex [12,13] and a higher eccentric overload during LPJT [14] may have contributed to larger improvements in SSC efficiency, muscle activation, and stiffness of musculotendinous tissue. In view of the importance of sprint speed performance during soccer matches, LPJT seems to be preferable to UPJT in prepubertal male soccer players. However, technical competency must first be attained before the progression to loaded PJT formats.

Jumping tests

Jump performance has been shown to be a valid talent-identification marker which can discriminate between potential elite and non-elite youth soccer players.[33] In this study, both PJT protocols induced small performance improvements in the SLJ test. Regarding the CMJ test, while UPJT showed small training-related effects, the LPJT generated a moderate effect. In prepubertal male soccer players, jump performance improvements have frequently been observed following UPJT programs.[1,4,20] The novel finding of this study is that LPJT appears to generate further performance increases which seem mostly restricted to vertical jumping. Rosas et al. [16] studied the effects of 6 weeks LPJT or UPJT on vertical and horizontal jump performance in young male soccer players (aged 12 years). The study authors reported larger performance improvements in vertical and horizontal jump performance tests in the LPJT group (ES=0.26 to 0.47) than in the UPJT group (ES=0.26 to 0.32) and control group (ES=0.08 to 0.16). The greater vertical and horizontal jump performance enhancements were attributed to higher peak ground reaction forces and to greater vertical and horizontal impulses generated by LPJT.[16] In another study, Kobal et al.[15] studied the effects of 6 weeks of LPJT, using handheld dumbbells, or UPJT on measures of muscle power and speed in elite young male soccer players (aged 16 years). The researchers reported higher increases in SJ (Δ8.4%) and CMJ (Δ9.4%) in the LPJT group compared to the UPJT group (SJ: Δ4.6% and CMJ: Δ4.9%). Again, it was speculated that these improvements were due to increased vertical ground reaction force over a shorter time period which may have resulted in a higher impulse related to the addition of load during PJT, and greater jump performance adaptations in the LPJT group. [16] Overall, prepubertal male soccer players can improve their vertical and horizontal jump performance by means of PJT executed either with or without additional load stimuli. However, there seems to be an advantage in the utilisation of LPJT over UPJT programmes in terms of the magnitude of the training-related effects on vertical jump performance.

Maximal kicking distance

Effective kicking is a vital and necessary skill that is performed during soccer matches, as it is the method used to score most goals.[34] In this study, MKD improved to a small magnitude after UPJT and increased moderately following LPJT. Reinforcing our results, Rosas el al.[16] demonstrated greater maximal kicking velocity improvements in LPJT (effect-size=0.34) and UPJT (effect-size=0.27) groups as compared to a control group (effect-size=0.15), following 6 weeks of training. Improvements in some biomechanical parameters involved in kicking the ball (e.g., the maximum linear velocity of the toe, ankle, knee, and hip at ball contact), due to neuromuscular adaptations,[20] could explain MKD performance increases. The larger MKD improvements following LPJT may be induced by greater levels of muscle activation, [13] resulting in increases in force production and rate of force development. However, findings should be interpreted with caution because MKD can be influenced by several extraneous factors such as the trajectory and rotation of the ball, as well as the technique used to kick the ball (i.e., toe, dorsum or the inside part of the foot).[35] This might affect kicking performance irrespective of the level of muscle power.

This study does have some limitations. First, we were unable to include an active control group. Second, the study lacks direct physiological and/or biomechanical measures that may help explain the underpinning mechanism behind the observed improvements in prepubertal soccer players. This has to be considered in future research.

PRACTICAL APPLICATIONS

Larger increases in measures of muscle power, speed, CoD and kicking-distance performance have been shown following LPJT as compared to UPJT in prepubertal male soccer players. These study findings contribute to previous knowledge on the delivery of effective PJT programs to prepubertal male soccer players. UPJT has already been well-established as beneficial for improving several physical fitness components of prepubertal male soccer players. The novelty in the current study is that LPJT appears to be more effective than UPJT in further enhancing the main components of physical fitness (i.e., speed, muscle power, and CoD) required by soccer competition, thus representing an effect progression of exercise that can be used to drive continual adaptation. Based on the findings reported herein, practitioners are recommended to use LPJT to improve components of physical fitness in prepubertal male soccer players, but technical competency in unloaded jumps should first be established.

CONCLUSIONS

Outcomes of this study suggested that LPJT is more effective than UPJT in improving measures of muscle power, speed, CoD and kicking-distance performance. Future longitudinal studies should establish what physiological and biomechanical adaptations are responsible for the observed functional adaptations.

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CONFLICT OF INTERST

The authors declare no conflict of interest.

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Table 1: Anthropometric characteristics of the included subjects

	UPJT (n=16)		LPJT (n=13)	
	Pre-test	Post-test	Pre-test	Post-test
Age (years)	13.0±0.5	13.2±0.5	13.0±0.7	13.2±0.7
Body height (cm)	159.6±11.6	160.3±11.7	162.6±8.3	162.8±8.4
Body mass (kg)	42.4±8.8	41.6±10.8	45.7±8.0	46.5±7.4
Maturity offset (years)	-1.3±1.1	-1.2±1.2	-1.1±0.5	-1.0±0.5
Predicted APHV (years)	14.3±0.8	14.4±0.9	14.1±0.6	14.1±0.6

Data are presented as means and standard deviations (SD); UPJT: Unloaded plyometric jump training group; LPJT: Loaded plyometric jump training group; APHV: Age at peak-height-velocity.

Table 2: Characteristics of the plyometric jump training programs

Week	Plyometric exercises*	Volume (sets×reps)	Ground contacts per session
1	Bilateral forward ankle hops (hurdle height: 20 cm)	4 × 6-7	50
	CMJ	4 × 6-7	
2	Bilateral forward ankle hops (hurdle height: 20 cm)	4 × 7-8	60
	CMJ	4 × 7-8	
3	Bilateral forward ankle hops (hurdle height: 20 cm)	4 × 8-9	70
	CMJ	4 × 9	
4	Bilateral forward ankle hops (hurdle height: 20 cm)	4 × 10	80
	CMJ	4 × 10	
5	Bilateral forward ankle hops (hurdle height: 20 cm)	4 × 10	90
	CMJ	6 × 8-9	
6	Bilateral forward ankle hops (hurdle height: 20 cm)	6 × 8-9	100
	CMJ	6 × 8-9	
7	Bilateral forward ankle hops (hurdle height: 20 cm)	6 × 8	110
	CMJ	6 × 10	
8	Bilateral forward ankle hops (hurdle height: 20 cm)	6 × 10	120
	CMJ	6 × 10	

*Reps: repetitions; CMJ: countermovement jump; * The loaded plyometric jump training group conducted plyometric exercises with weighted vest, while athletes of the unloaded plyometric jump training group performed the same exercises with their body mass load only.*

Table 3: Within-group effect sizes, confidence limits, likelihood effects and odds ratios for performance data

Variable	Baseline	Post-test	Effect size	Confidence limits	Chances (%) Beneficial/trivial/harmful	Effect description	Odd ratio of benefits to harm
Unloaded plyometric jump training group (n=16)							
ICoD test (s)	18.6±1.1	18.2±1.1	0.36	-0.2 to 0.9	77.8/21.5/0.8	Likely beneficial	454
Modified 505 CoD test (s)	2.9±0.2	2.8±0.2	0.50	-0.1 to 1.1	84.4/14.3/1.3	Likely beneficial	409
5-m sprint (s)	1.2±0.1	1.1±0.1	1.00	0.4 to 1.6	90.9/6.5/2.5	Likely beneficial	373
10-m sprint (s)	2.1±0.1	2.0±0.2	0.63	0.0 to 1.2	87.5/10.8/1.8	Likely beneficial	391
20-m sprint (s)	3.7±0.3	3.6±0.3	0.33	-0.3 to 0.9	75.2/24.2/0.6	Likely beneficial	473
CMJ (cm)	23.7±4.8	26.6±5.4	0.57	0.0 to 1.2	86.2/12.2/1.5	Likely beneficial	398
SLJ (m)	1.6±0.2	1.7±0.2	0.50	-0.1 to 1.1	84.4/14.3/1.3	Likely beneficial	409
MKD (m)	23.4±5.2	26.2±6.0	0.50	-0.1 to 1.1	84.4/14.3/1.3	Likely beneficial	409
Loaded plyometric jump training group (n=13)							
ICoD test (s)	18.6±0.6	18.2±0.7	0.61	0.0 to 1.3	87.4/10.8/1.8	Likely beneficial	379
Modified 505 CoD test (s)	2.9±0.0	2.7±0.1	2.83	1.9 to 3.7	93.8/2.2/4.0	Likely beneficial	362
5-m sprint (s)	1.3±0.1	1.2±0.1	1.00	0.3 to 1.7	91.0/6.3/2.7	Likely beneficial	368
10-m sprint (s)	2.2±0.1	2.0±0.1	2.00	1.2 to 2.8	93.3/3.1/3.7	Likely beneficial	363
20-m sprint (s)	3.8±0.2	3.6±0.2	1.00	0.3 to 1.7	91.0/6.3/2.7	Likely beneficial	368
CMJ (cm)	22.3±4.4	27.1±5.1	1.00	0.3 to 1.7	91.0/6.3/2.7	Likely beneficial	368
SLJ (m)	1.7±0.2	1.8±0.2	0.50	-0.2 to 1.2	84.7/13.9/1.4	Likely beneficial	388
MKD (m)	25.0±4.6	29.5±5.4	0.90	0.2 to 1.6	90.4/7.1/2.5	Likely beneficial	369

COD: change of direction; ICoDT: Illinois change of direction test; CMJ: countermovement jump; SLJ: standing long jump; RSI: reactive strength index; MKD: maximal kicking distance.

Table 4: Between-group effect sizes, confidence limits, likelihood effects and odds ratios for performance data

Variable	Mean difference	Effect size	Confidence limits	Chances (%) Unloaded is beneficial / Similar / Loaded is beneficial	Effect description	Odd ratio of benefits to harm
ICoD test (s)	0.00	0.00	-0.6 to 0.6	0.0/100.0/0.0	Most likely similar	0
Modified 5-0-5 CoD test (s)	-0.09¥	0.61	0.0 to 1.2	1.9/11.5/86.9	Likely beneficial	409
5-m sprint (s)	-0.02£	1.00	0.4 to 1.6	90.8/6.7/2.5	Likely beneficial	378
10-m sprint (s)	0.00	0.00	-0.6 to 0.6	0.0/100.0/0.0	Most likely similar	0
20-m sprint (s)	0.00	0.00	-0.6 to 0.6	0.0/100.0/0.0	Most likely similar	0
CMJ (cm)	0.53¥	0.09	-0.7 to 0.5	0.0/96.5/3.5	Very likely similar	6442
SLJ (m)	0.08¥	0.50	0.1 to 1.1	1.2/14.6/84.2	Likely beneficial	434
MKD (m)	3.32¥	0.57	0.1 to 1.2	1.5/12.4/86.2	likely beneficial	416

¥ Mean difference in favor of the loaded plyometric jump group; £ Mean difference in favor of the unloaded plyometric jump group

COD: change of direction; ICoDT: Illinois change of direction test; CMJ: countermovement jump; SLJ: standing long jump; RSI: reactive strength index; MKD: maximal kicking distance.