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Four-week progressive unilateral plyometric training improves vertical jump height in youth football goalkeepers

Luthfi Adhitya, Jeki Haryanto*), Vega Soniawan, Ikhwanul Arifan
Universitas Negeri Padang, Padang, West Sumatra, Indonesia

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ABSTRACT

Goalkeepers perform a vertical jump with one-leg many times when contesting crosses, corners, and lofted passes while plyometric training studies that are related to football have mainly concentrated on outfield players, thus leaving the position-specific evidence for goalkeepers scarce. This study investigated the impacts of unilateral plyometric training program of 16 sessions on the explosive power of lower limbs of youth football goalkeepers. Using a quasi-experimental one-group pretest-posttest design, six male goalkeepers (13.8 ± 1.5 years; 4.2 ± 1.1 years of playing experience) recruited by purposive sampling from a community football academy in Padang, Indonesia participated in the study. The vertical jump wall-and-chalk test was used to assess lower limb explosive power, with the best of three jumps used for analysis. The training intervention involved eight progressive variations of the cone-assisted single-leg plyometric exercises carried out in 16 sessions (four times a week for four weeks), three sets of eight, seven and six repetitions at 90%, 95% and 100% maximal effort respectively, with 1-3 min inter-set and 5 min inter-drill recovery were prescribed. Normality was verified through the Lilliefors test, variance homogeneity through an F ratio, and the hypothesis through a paired-samples t-test complemented by standardised effect sizes and 95% confidence intervals. Vertical jump height rose from 29.83 ± 9.15 cm to 34.67 ± 9.31 cm, a mean increase of 4.83 cm (95% CI [1.98, 7.68]), t(5) = 4.36, p = .007, dz = 1.78. Each participant enhanced their performance (range 2-10 cm; +16.2% group mean). Therefore, short-cycle unilateral plyometrics can be considered as a low-cost, equipment-light strategy that coaches can easily integrate into regular goalkeeper training sessions to improve aerial-dual readiness.

Corresponding Author:

Jeki Haryanto,
Universitas Negeri Padang, Padang, West Sumatra, Indonesia
Email: Jekiharyanto@fik.unp.ac.id

Introduction

As a team game, football can require a large number of short, intense bursts of activity. The ability to generate force rapidly in such circumstances is what separates different competitive levels more reliably than one's aerobic capacity alone. To jump, accelerate, decelerate and change direction require an efficient stretch-shorten cycle (SSC) as all these movements depend on it. The SSC is the neuromechanical sequence where an eccentric pre-stretch potentiates a subsequent concentric contraction. The cross-sectional profiling of youth academies at the elite level has established that SSC indices differentiate age groups and playing positions, which leads to the interpretation that physical training, especially in the development of children, needs to be focused on the specific position rather than being uniform across the whole team (Škorik, Sýkora, et al., 2026). Regarding other studies, maximal and relative strength of lower limbs have a strong association with jump and sprint outcomes in elite

youth players (Kadlubowski et al., 2024; Fahey et al., 2025), resulting in lower-limb explosive power becoming a key focus of youth physical development.

As a method to develop the quality of power, plyometric jump training (PJT) has been adopted widely because it facilitates rapid force production within the joint angles and modalities of contraction velocities that resemble the athlete's competitive actions. According to a systematic review of plyometric interventions in football, there have been quite consistent improvements in jumping, sprinting, and agility through a wide range of different plyometric protocols and across different competition levels (Firmansyah et al., 2024). Some of the recent randomised controlled trials in youth populations also support the arrival at these conclusions (Holík et al., 2026; Türkarslan & Deliceoglu, 2024). According to meta-analytical synthesis, adolescent players react to PJT with maturation-dependent gains in lower-extremity explosive strength (Chen et al., 2024), whereas parallel improvements in physical fitness with reductions in inter-limb asymmetry have been reported in randomised trials of prepubertal players (Sammoud et al., 2024). Furthermore, it has also been shown that even significantly lower doses can be effective: microdosed plyometric programs have enhanced jump height, reactive strength index and acceleration in youth players (Liu et al., 2024) and have even been able to preserve physical qualities of an explosive nature throughout the preseason (Škorik, Kalina, et al., 2026).

The rarity of the isolation of plyometric jump training (PJT) sessions in practice has lead to a great deal of research investigating the combined training situations. Training interventions that combined plyometric training with strength, speed, and change-of-direction work have demonstrated superior adaptations that are composite compared to traditional conditioning (Muñoz et al., 2024; Martín-Moya et al., 2023; Aloui et al., 2022), while plyometric–sprint-interval hybrids enhance both neuromuscular and metabolic markers (Yang et al., 2024; Selmi et al., 2026). New reviews have endorsed cluster-set and contrast formats (Öztürk et al., 2025) and integrative neuromuscular training (INT) frameworks as being effective at both simultaneously enhancing athletic performance and mitigating injury risk (Armiento et al., 2026; Jiang et al., 2026; Turan et al., 2025; Belamjahad et al., 2025).

Programme variables that modulate the response are increasingly well characterised, including: vector orientation (Moran et al., 2024; Kurt et al., 2023), the specific jump modality selected (Alves et al., 2026; Kokinda et al., 2023), weekly frequency and season phase (Siby et al., 2025; Franco-Márquez et al., 2025; McGarrigal et al., 2025), training surface (Modena et al., 2025; Laksono & Suharjana, 2024; Richardson et al., 2025), set configuration (Öztürk et al., 2025), balance integration (Sinulingga et al., 2025), and biological maturity as a moderator (Marzouki et al., 2023; Bouafif et al., 2026).

The first thing to notice from this literature is that almost all of the findings come from studies with outfield players whose performance model is dominated by repeated horizontal accelerations. However, goalkeepers run a lot less but they do disproportionate numbers of maximal vertical and lateral propulsions that are initiated from a stationary or near-stationary position, often coming off a single limb, to stop crosses, corner kicks, and lofted passes. Position-specific SSC profiling corroborates the distinctiveness of this demand (Škorik, Sýkora, et al., 2026) but as far as we know, only one published pilot study to date has looked at plyometric training specifically for goalkeepers and that study focused on ball-blocking performance in penalty situations rather than vertical power (Dawood, 2025). Second, in the few studies that have looked at unilateral loading, it has generally been in the context of asymmetry reduction or agility with jump height being secondary and the results have been mixed: amateur players who underwent unilateral strength and power training had their inter-limb asymmetry reduced but not all of them had their performance improved (Bettariga et al., 2023), unilateral and bilateral plyometric exercises produced similar agility and acceleration adaptations (Mujezinović et al., 2024), and direct comparisons in prepubertal and pubertal youth suggest that the superiority of either modality is maturity-dependent (Dardouri et al., 2026). Nevertheless, single-leg formats such as bounding and single-leg jumps have been demonstrated to have favorable changes on sprint and jump kinematics (Johansen et al., 2025; Galeko et al., 2022).

The come-together of these two gaps is what basically identifies the present research problem. Goalkeeping is the football position most reliant on unilateral vertical propulsion, but it is also the position where the whether a unilateral plyometric training can improve vertical jump has not been supported by research thus far. This imbalance is even more pronounced in community academy settings of football development where goalkeeper sessions are normally focused on technical training - catching, positioning and diving - and lower limb power development is either absent or is borrowed directly from outfield programming. At the academy studied here, this was additionally accompanied by performance that was below optimal in aerial duels. Therefore, whether a short, equipment-light and progressively loaded unilateral plyometric block can meaningfully alter vertical jump performance in such a setting has direct applied value particularly because plyometric training requires minimal facilities and it is doable where force plates, gym access and strength equipment are not available (Matsuda et al., 2024; Boraczyński et al., 2023).

Although numerous studies have examined plyometric training in youth football players, almost all focused-on outfield players, while evidence regarding unilateral plyometric training specifically for goalkeepers remains extremely limited. Hence, the scientific contribution and research aims of this study are threefold: a) it addresses a position that has been systematically underrepresented in the plyometric literature; b) it investigates a purely unilateral, cone-assisted format rather than the combined or bilateral protocols that dominate previous trials (Dawood, 2025); and c) it is done in a resource-limited Southeast Asian academy, a rarely represented context in indexed sport-science output. Therefore, the purpose of this study was to evaluate the effects of a 16-session progressive unilateral plyometric program on lower-limb explosive power, measured as vertical jump height, in youth football goalkeepers. The assumption was that the performance of the vertical jump would be significantly enhanced post the intervention.

Method

Study design

A quasi-experimental one-group pretest-posttest design was utilized. Since the number of active goalkeepers within the participating academy was very limited and not sufficient for randomization to parallel groups without loss of statistical power, the authors decided to conduct a single-group pretest-posttest design. In football research that targets position-specific aspects, encountering such a limitation situation is not unusual (Dawood, 2025). The unilateral plyometric training program was the independent variable, while lower-limb explosive power as vertical jump height was the dependent variable. Both training and testing happened at the academy training ground in Padang, West Sumatra, Indonesia.

Participants and sampling

The source population was all 86 registered players aged from 10 to 16 years. Selection of the participants was done through purposive sampling and they had to meet three a priori criteria: (a) registered and actively training as a goalkeeper, (b) male, and (c) able to commit to the full training block and both testing sessions. After screening for these criteria, six goalkeepers were selected and underwent the complete training block without any dropout or injury (attendance = 100%). The participants and their legal guardians were explained the procedures both in written and verbally, and written informed consent from guardians was obtained before baseline testing. Participants could withdraw from the study at any time without any consequence. Table 1 contains the descriptive characteristics. The study was conducted with due regard to the Declaration of Helsinki. The institutional permission was granted by the management and coaching staff of the participating academy, and written informed consent was obtained from all legal guardians. Since the study involved the total population of eligible goalkeepers within the academy, a convenience census approach was adopted. Therefore, no participants meeting inclusion criteria were excluded.

Instrument and measurement procedure

The wall-and-chalk vertical jump (Sargent) test was used for testing explosive power of lower limbs. It is a field protocol that is very commonly used in places where laboratory equipment is not available. The standing reach was measured first with the participant standing side-on to a flat vertical wall, he had both feet together and flat on the ground, and the dominant arm was fully extended overhead with the chalked fingertips. Then, the participant performed a maximum vertical jump with a countermovement from a static position without an approach run and marked the wall with the chalk at the height of the fingertip at the apex of flight. Vertical jump height was computed as the difference between the jump reach and the standing reach. The participant was allowed to perform 3 attempts with sufficient recovery time, and the highest value was taken for all the subsequent analyses. A trial would be judged invalid and be repeated if the participant did not manage to hit the chalk mark at the apex, or if the participant used a running start. The performance was interpreted against the established norms (excellent 60-70 cm; good 50-59 cm; average 40-49 cm; poor 30-39 cm; very poor 20-29 cm).

Although force platforms and inertial measurement units allow assessment of jump kinetics with higher precision and are being increasingly validated for field use (Dos'Santos et al., 2024; de Ruiter et al., 2024), the wall-and-chalk test was chosen for practical and ecological reasons: it does not require electrical power, it is carried out on the training surface, and it is in keeping with the land and equipment constraints of community academies. The same investigator took all the measurements at the same time of day and on the same surface, the warm-up was a standardised 15-min session comprising light jogging, dynamic mobility and three submaximal vertical jumps to minimise measurement variability.

Intervention

The participants after baseline testing went through 16 consecutive training sessions supervised and delivered four times in one week in addition to their regular technical practice. Each session was composed of the following elements: the opening routine and a 15-minute warm-up, main plyometric block, a small sided game (5 vs 5) to effectively bring back the stimulus into the game environment, and a cool down to get the heart rate back down to 80~100 bpm level. The main block consisted of eight cone-assisted single-leg plyometric models done with alternating take-off legs, ensuring that each leg is separately exercised within every set. To follow SSC training, the programme took the inverse volume – intensity relationship (IVI) wherein relative intensity was increased and volume was decreased. All the training parts consisted of three sets and the time given for inter-set recovery was 1-3 minutes. This recovery time was adjusted based on individual heart rate response and the longer 5-minute period between drills was kept to maintain the quality of the movements (Table 2). Post-testing was performed 48 h after the last session in a situation that was exactly the same as the baseline one.

Statistical analysis

Initially, raw field record sheets were compared with the entered data and data entry errors were identified and corrected. Descriptive statistics are reported as mean ± standard deviation, with median, range and standard error. Distributional normality was examined with the Lilliefors test ($\alpha = .05$; critical value $L = 0.319$ for $n = 6$) and corroborated with the Shapiro–Wilk statistic. Homogeneity of variance between the pre- and post-test distributions was evaluated with an F ratio of the larger to the smaller variance and cross-checked with Levene's test. The research hypothesis was tested with a paired-samples t-test (two-tailed, $\alpha = .05$, $df = 5$, t critical = 2.571). Since null-hypothesis significance testing is uninformative about magnitude in small samples, the mean difference has been reported with a 95% confidence interval, and standardised effect sizes have been expressed as Cohen's dz with the Hedges correction for small-sample bias; thresholds of 0.20, 0.50 and 0.80 were used to denote small, moderate and large effects. The distribution-free Wilcoxon signed-rank test was run as a sensitivity analysis. Individual response data are presented in full so that readers may evaluate response consistency independently of the group mean. Computations were performed in Microsoft Excel and verified with an independent statistical routine.

Results and Discussions

Descriptive statistics

After the intervention, the group average vertical jump height increased to 34.67 ± 9.31 cm from 29.83 ± 9.15 cm; an absolute increase of 4.83 cm and a relative increase of 16.2%. Values for both the minimum (20 - 25 cm) and maximum (43 - 47 cm) increased and the median rose from 29.00 cm to 34.50 cm (Table 3). A large part of this upward movement was made up by a drop in the proportion of goalkeepers in the lowest band from 50.0% to 33.3% and the doubling in the proportion reaching the "average" band from 16.7% to 33.3% (Table 1). However, no participant reached the "good" or "excellent" bands at either time point.

Table 1. Descriptive statistics for vertical jump height (cm) before and after the intervention

Interval (cm)	Category	Pre-test f	Pre-test %	Post-test f	Post-test %
60–70	Excellent	0	0.0	0	0.0
50–59	Good	0	0.0	0	0.0
40–49	Average	1	16.7	2	33.3
30–39	Poor	2	33.3	2	33.3
20–29	Very poor	3	50.0	2	33.3
Total		6	100.0	6	100.0

Note. f = absolute frequency. Vertical jump score categories follow the conventional normative bands for male athletes.

Assumption testing

The normality assumption was met by all distributions: the Lilliefors statistics observed were less than the critical value of 0.319 for $n = 6$ at $\alpha = .05$ (Table 5), and the Shapiro–Wilk test results were non-significant for the pre-test ($W = .937$, $p = .634$), post-test ($W = .897$, $p = .355$), and change scores ($W = .799$, $p = .057$). Variance homogeneity was also supported, $F(5, 5) = 1.04$, $p = .486$, well below the critical value of 5.05; Levene's test was in agreement ($F = 0.06$, $p = .818$). Parametric analysis was thus suitable.

Table 2. Summary of normality and homogeneity testing

Variable	L observed	L critical	Decision
Pre-test	0.166	0.319	Normal
Post-test	0.192	0.319	Normal
Change score	0.309	0.319	Normal

Note. The Lilliefors test is a normality test, $\alpha = .05$, $n = 6$. Homogeneity of variance: $F(5, 5) = 1.04$, $p = .486$.

Hypothesis test and effect size

The paired-samples t-test showed a statistically significant increase in vertical jump height, $t(5) = 4.36$, $p = .007$, with the observed t value being higher the critical value of 2.571; thus, there was a rejection of the null hypothesis. The mean improvement of 4.83 cm was supported by the 95% confidence interval that did not include zero [1.98, 7.68] and by a large standardised effect size (dz = 1.78; Hedges g = 1.50). The non-parametric sensitivity analysis gave the same results (Wilcoxon signed-rank test, $p = .031$). The summary of the results is presented in Table 6.

Table 3. Paired-samples t-test, confidence interval and effect size for the pre–post comparison

Comparison	M difference	SD difference	95% CI	t(5)	p	dz	Hedges g
Post-test – Pre-test	4.83	2.71	[1.98, 7.68]	4.36	.007	1.78	1.50

Note. CI = confidence interval; dz = Cohen's d for paired samples; Hedges g = small-sample corrected effect size. Two-tailed test, $\alpha = .05$, t critical = 2.571.

Individual responses

All six individuals improved their performances, the least gain was 2 cm and the highest gain was 10 cm (Table 7). Percentage improvement in the range of 5.4% to 31.3% was the largest amongst goalkeepers which had their baseline values nearest the group mean, whereas baseline highest performing participant recorded smallest relative change. There was a very strong pre-post correlation ($r = .96$), which shows that an individual's ranking was largely preserved despite the group-level shift.

Table 7. Individual vertical jump performance before and after the intervention

Participant	Standing reach (cm)	Pre-test (cm)	Post-test (cm)	Change (cm)	Change (%)
GK1	228	26	30	+4	15.4
GK2	205	20	25	+5	25.0
GK3	200	37	39	+2	5.4
GK4	210	21	25	+4	19.0
GK5	190	43	47	+4	9.3
GK6	207	32	42	+10	31.3
M	206.67	29.83	34.67	+4.83	17.6

Note. Vertical jump height = maximum jump reaches out of three trials minus standing reach. Change (%) in final row is the average of individual percentage changes.

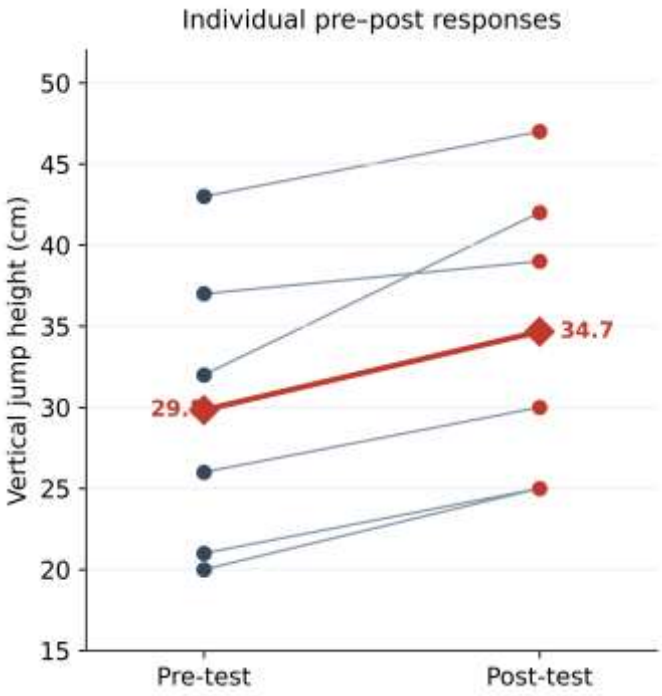

Figure 1. Individual pre–post

Individual pre–post vertical-jump responses. Thin grey lines show each goalkeeper; the bold red line and diamonds show the group mean. All six goalkeepers improved (uniformly upward slopes). Jump height in centimetres.

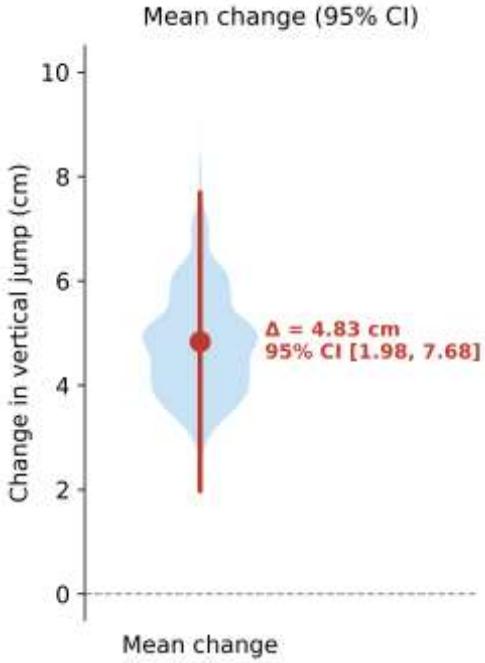

Figure 2. Mean change

Mean change with 95% confidence interval (estimation plot). Red marker = mean change (+4.83 cm); red bar = 95% CI [1.98, 7.68]; shaded shape = bootstrap distribution of the mean change; dashed line = no change. The interval excludes zero but is wide, reflecting n = 6.

This research aimed to find out if a short, unilateral plyometric training block that was progressively loaded would enhance youth football goalkeepers' lower-limb explosive power. The main result showed a clear positive effect: vertical jump height increased by 4.83 cm on average (+16.2%), the effect was statistically significant, the confidence interval comfortably excluded zero, and the standardised effect was very large. Moreover, the effect

was not only statistically significant but practically very large. The data indicate that every player improved, in fact, all six players showed positive responses. This sort of result, in small samples, is even more convincing than p values because it eliminates the possibility that the group mean was inflated by one or two outstanding performers.

Magnitude and plausibility of the observed adaptation

The 16.2% improvement in just four weeks is quite a large result compared to the youth football studies, but not outside of what they have reported overall. Previous randomized trials on plyometric programs for young players reveal vertical jump gains between about 5% to 15% over six to twelve weeks (Türkarslan & Deliceoglu, 2024; Holík et al., 2026; Kurt et al., 2023). Also, meta-analytic results in adolescents show that plyometric training has a moderate-to-large effect on lower-extremity explosive strength and that this effect seems to be greater around the time of peak height velocity (Chen et al., 2024). Our protocol has three main characteristics that can explain why our participants' results were closer to the higher end.

Firstly, initial perfomance was low: the group average of 29.83 cm placed half of the sample in the lowest normative band, and it is well known that players who have more room for improvement tend to show the steepest gains initially. Secondly, the frequency of the training sessions - four times a week - was quite high compared to the usual two-to-three sessions reported in the literature (e.g., the three-session protocol of Siby et al., 2025). This way, a substantial total stimulus is packed into a short time block. Thirdly, the participants had not been exposed to plyometric training before, so it is reasonable to assume that a large part of the gain during the early phase of adaptation was due to neural rather than structural changes.

On the other hand, one must recognise that such a short four-week block is quite unusual when looking at the whole body of research, and without a control group it is simply not possible to attribute the effects solely to the plyometric training since technical training, test familiarity, or growth could have contributed. Studies which implement control groups usually show that the effects net of these other factors are smaller than pre-post differences without controls (Sammoud et al., 2024; Bouafif et al., 2026), so the present large effect size might be considered the maximum effect that the program could deliver alone.

Mechanisms underlying the improvement

The working hypothesis is that the main mechanism is enhanced efficiency of the stretch–shortening cycle (SSC). In plyometric loading, the musculotendinous unit undergoes an eccentric pre-lengthening phase rapidly followed by a concentric contraction. With regular plyometric training, the storage and recovery of elastic energy within the tendon improves, so does the high eccentric load tolerance, and there is a decrease in the duration of the transition phase (amortisation phase). According to Škorik, Sýkora, et al., (2026) different aspects of the SSC development (slow vs fast) in youth players follow separate developmental patterns and in their in-season longitudinal study plyometric training was shown to induce changes in both slow and fast SSC functionalities independently from maturation (McGarrigal et al., 2025). Since a goalkeeper's jump to win an aerial duel is a very brief contact, fast-SSC type of action, it is exactly the functional area that the intervention should have trained.

Another major mechanism is neural. The earliest changes in motor units, recruitment frequency, intermuscular coordination, and reduced antagonist co-activation are seen in untrained or plyometrically naïve individuals, before any hypertrophy is noticed. This explanation fits well with the fact that the two types of training, plyometric loading and heavy resistance loading, differ mechanistically to a great extent but have similar short-term neuromuscular gains (Boraczyński et al., 2023). It is also in line with the sensitivity of jumping to set structure and inter-set recovery which has been demonstrated even through acute changes (Öztürk et al., 2025; Köklü & Alptekin, 2026). The four-week duration of the present block falls mostly within the neural adaptation window.

The third factor that potentially played a role is the fact that the training was purely unilateral. By training each limb separately the stronger limb is no longer able to compensate for the weaker one, a compensation that is well elicited in bilateral jumps. According to Bettariga et al. (2023), unilateral strength and power training has been proven to be effective in decreasing inter-limb muscular asymmetry in football players. Single-leg jump tests have been shown to reliably detect functional asymmetries, which are often concealed during bilateral tests (Sammoud et al., 2024; Mujezinović et al., 2024). Since the vertical jump test utilized in this study was a bilateral one, any unilateral training-induced asymmetry reduction would manifest as a more symmetrical, hence more efficient, bilateral take-off, which is a reasonable explanation of how unilateral training led to a bilateral performance enhancement.

Agreement and disagreement with previous studies

The direction of the present finding aligns with the dominant conclusion of the football plyometric literature. The systematic review by Firmansyah et al. (2024) reported consistent jump improvements across heterogeneous protocols, and recent randomised trials in youth cohorts have reproduced this result using varied formats including microdosed prescriptions (Liu et al., 2024; Škorik, Kalina, et al., 2026), combined plyometric–sprint models (Yang et al., 2024; Aloui et al., 2022; Selmi et al., 2026), plyometric–strength–speed integration (Muñoz et al., 2024; Franco-Márquez et al., 2025) and integrative neuromuscular frameworks (Armiento et al., 2026; Turan et al., 2025; Jiang et al., 2026; Belamjahad et al., 2025). Findings in Indonesian football populations using single- and double-leg hop protocols (Galeko et al., 2022) and sand- versus land-based plyometrics (Laksono & Suharjana, 2024) are likewise congruent with the present result, supporting its transferability within this training culture.

The agreement is not complete when considering unilateral versus bilateral loading. For instance, Mujezinović et al. (2024) found that unilateral and bilateral plyometric exercises resulted in similar improvements in planned agility and acceleration. Dardouri et al. (2026) showed that the relative benefit of unilateral jump training varies with maturity level, with pubertal and prepubertal players responding differently. Johansen et al. (2025) also noted that bounding and single-leg jump training affected sprint and jump kinematics through partly different mechanisms. This current study cannot decide between these modalities as no bilateral comparison arm was included. However, what it does show is that a purely unilateral format can produce a large bilateral jump improvement in this population. Since maturation influences the response (Marzouki et al., 2023; Bouafif et al., 2026; Chen et al., 2024) and the present sample was drawn from a broad 10–16-year age band, some of the between-individual variation in Table 7 - gains ranging from 2 cm to 10 cm - may plausibly be due to maturational heterogeneity that could not be quantified here.

On another note, the chosen outcome of the studies also presents a difference. The previous plyometric program that used only goalkeepers was about ball-blocking in penalty kicks (Dawood, 2025), a skill quite different from a vertical jump. One could argue that the two types of tests complement each other as different abilities are evaluated, penalty-saving is mostly lateral reactive diving whereas in the air, the player uses vertical jumping to be the first and control the ball. Taken together, the two works indicate the emergence of a position-specific body of knowledge about how goalkeepers adapt to plyometric exercises in different directions. That would support the general finding that plyometric exercises whether performed horizontally, vertically, or combined are associated with adaptations specific to the direction.

Theoretical Implication

From a theoretical standpoint, the findings of this research support a shift in the focus of training specificity towards a particular aspect of literature that has mostly been side-tracked. While specificity is typically used to justify the alignment of training sessions with the demands of a particular sport, this study's finding implies the principle should also be used to align training in terms of laterality with the specific requirements of a position. A footballer goalkeeper, for instance, mainly gets to jump with one foot and within a short time window; thus, having the training stimulus replicate the constraint would be expected to result in a very large adaptation. This finding is also an indication that role or position in sport teams is not merely descriptive but a real variable/moderator in youth physical development models (the same as with e.g. evidence that SSC characteristics differ systematically between positions (Škorik, Sýkora, et al., 2026) and that maximal strength correlates with jump performance in a position-dependent way (Kadlubowski et al., 2024; Fahey et al., 2025), that position plays a key role in differentiating performance factors). Besides that, we can expect a significant individual gain after plyometric exposure at the end of low training status continuum from this observation of almost uniform response by individuals regardless of the initial abilities in a group of people with very low baseline abilities.

Practical implications

For coaches the message is very clear: a substantial enhancement of the goalkeeper's vertical jumping capability can be performed just with cones, wall and training for 4 weeks without gym, equipment, or outside forces. Three main things were confirmed. First, allocate specially goalkeeping power session to lower-body power rather than take it for granted that doing technical drills will result in power; in the goalkeepers' technical training, which inspired this study, a lot of exercises focus on skill development leaving out power altogether. Second, keep the intensity gradually higher while repetitions get lower as they actually did here 3 sets of 8 reps with 90% weight and in the next step 3 sets of 6 reps with 100% weight and make sure recovery after each exercise is adequate so that each rep is maximum effort a fact that jump performance changes depending on how set-up and recovery are handled had been observed (Öztürk et al., 2025). Last is performing unilateral movements, i.e., exercises involving each limb separately, especially when there is a suspicion of interlimb

asymmetry one-leg vertical jump test should be done together with the training period (Bettariga et al., 2023; Sammoud et al., 2024). Apart from these, practitioners should also consider other factors that have been shown in previous literature to influence the outcome. For example, training surface can be a determinant of the reaction (Modena et al., 2025; Laksono & Suharjana, 2024; Richardson et al., 2025; Narvariya et al., 2024), the combination of balance and mobility work (Sinulingga et al., 2025), warm-up content (Köklü & Alptekin, 2026) and season phase (Franco-Márquez et al., 2025; McGarrigal et al., 2025). Because of possible long-term injury prevention benefits of multimodal motor skills development such as those used in integrative neuromuscular training (Jiang et al., 2026; Turan et al., 2025), it is probably a wise decision to incorporate unilateral plyometrics, which the study describes quite in detail, not separately, but only as one of the components of the overall neuromuscular approach.

Limitations

First, our sample of only six goalkeepers is relatively small. Although this group accounted for 100.0 of all eligible individuals in the academy, the low statistical power of such a small sample and the limited generalisability outside our setting means, for instance, the wide confidence interval around the mean gain (1.98, 7.68 cm) actually points directly and precisely to the low power of the study. Since we did not include any control or comparison group, we could not rule out that maturation in addition to concurrent technical training and familiarisation with the test were the factors that brought on the improvements. We did not obtain anthropometric and maturity assessment data which could have been used to adjust for biological age, a factor known to affect the extent of plyometrics adaptation through the different studies (Marzouki et al., 2023; Chen et al., 2024; Bouafif et al., 2026). While the wall-and-chalk protocol that we used is known to be both a convenient approach and the most popular one, we admit that in comparison to more expensive devices as the force-platform or inertial-sensor assessment (Dos'Santos et al., 2024; de Ruiter et al., 2024); it provides only indirect and fairly inaccurate results, without yielding any kinetic measurements such as reactive strength or rate of force development. Therefore, it cannot be said definitely if the training programme was effective. The duration of four weeks and the lack of follow-up tests have resulted in our being uncertain about the long-term effects of the adaptation of the trainees. We should remember in this connexion that according to studies of detraining, the presence of a coach is important to preserve gains between breaks.

Future research on goalkeepers should focus on the inclusion of multi-club, goalkeepers in order to gain a sufficient level of power and compare the effectiveness of the different interventions. A bilateral plyometric comparison should be conducted to test the laterality hypothesis directly. It would be useful to classify or take into account maturity status. Taking the measures of ground reaction force via force platforms or inertial sensors would allow jump height to be divided into the respective kinematic (i.e., how the body moves) and kinetic (i.e., the forces) components and further reveal whether unilateral loading primarily leads to a reduction in asymmetry, a shortening of contact time, or a peak-force increase. Broadening the outcome measures to include those of goalkeeping-specific criteria tasks such as being successful in aerial-duel, ability to cross-claim, and capability to lateral-diving-reach would allow to determine in laboratory-conditions gained performance whether it really results in an improvement to goalkeeper performance, thus supporting the penalty-blocking method by Dawood (2025). Frequent practice session with follow-up test, and comparison of the effect of frequent small practice sessions versus fewer extended ones in goalkeepers (Liu, et al., 2024; Škorik, Kalina, et al., 2026), would contribute to figuring out how to best plan this training program throughout the season.

Conclusions

A research project involving sixteen progressive unilateral plyometric training sessions that used cones resulted in youth football goalkeepers experiencing, statistically significant as well as practically substantial, improvement in lower-limb explosive power (i.e., vertical jump height increased by +4.83 cm [+16.2%]). All participants showed positive responses. One of the reasons this piece stands out is because it focuses the attention on a playing position (i.e., goalkeeper) that has been virtually ignored in the plyometric literature while, at the same time, it introduces the idea of a purely unilateral training mode as an effective alternative to the standard combined or bilateral ones employed in most previous trials and it also provides an example case of a community club with limited financial resources that has a great success in a short time while relying essentially on only two training equipment: cones and a wall, without spending on anything else. On an academic level the work further extends the so-called specificity principle of training from the direction of movement vector to movement laterality and it supports, on the one hand, identifying a player's position as a variable factor and, on the other hand, a factor that has to be taken into consideration in the course of a child's physical development. At the same time, the practical part of the finding endorses making specific goalkeeper sessions the means to develop unilateral power through raising relative intensity, decreasing volume, along with protecting inter-set recovery as a way to progress. One has to take into account the limitations (the relatively small sample size, single-group

nature, short duration) before accepting and using these conclusions. The next studies should include controlled multi-site designs as well as maturity stratification, a comparison of bilateral groups, instrumented jump evaluation; the criterion outcomes should be specific to goalkeeping, and the testing of retention should provide insight into both the mechanism and the durability of the adaptation described.

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