Unipodal closed-chain lower body training and its effect on lower limbs asymmetries in junior players of the Chilean handball team

Entrenamiento unipodal del tren inferior en cadena cerrada y su efecto en las asimetrías de las extremidades inferiores en jugadores de categoría junior de la selección chilena de balonmano

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Abstract

Introduction. Handball is a high-intensity sport that imposes asymmetric loads on the lower limbs, especially in movements such as jumping and feinting.
Objective: This study aimed to identify asymmetries and assess the effect of a 12-week strength and power training program on the jumping ability of junior players of the Chilean handball team.
Methodology: With a quasi-experimental design, strength and plyometric exercises were applied in 12 microcycles. Each week included three 90-minute sessions before the technical-tactical training. 16 male junior players participated, with an average age of 20.6 ± 1.9 years, weight of 84.9 ± 8.4 kg and height of 183.8 ± 5.1 cm, and an average handball experience of 9 ± 2 years. The performance tests included squat jump (SJ), counter movement jump (CMJ), drop jump (DJ), from 30 cm and unipodal abalakov (ABK), using the "My Jump 2" application.
Results: The results showed a significant increase in jump height in all tests (p < .05), with improvements between 12% and 17% in SJ, ABK, CMJ and DJ. Body mass varied by 10% between initial and final assessments.
Discussion: Although there were no significant differences in initial and final asymmetries, a reduction in strength and power disparities was observed after the program, improving jump height performance.
Conclusions: The training program slightly reduced asymmetries and led to significant improvements in bipodal jumping ability in young handball players.

Keywords

handball; injury prevention; Plyometric training; strength training

Resumen

Introducción. El balonmano es un deporte de alta intensidad que impone cargas asimétricas en las extremidades inferiores, especialmente en movimientos como el salto y la finta.
Objetivo: Este estudio tuvo como objetivo identificar asimetrías y evaluar el efecto de un programa de entrenamiento de fuerza y potencia de 12 semanas en la capacidad de salto de jugadores junior de la selección chilena de balonmano.
Metodología: Con un diseño cuasi-experimental, se aplicaron ejercicios de fuerza y pliometría en 12 micro ciclos. Cada semana incluyó tres sesiones de 90 minutos antes del entrenamiento técnico-táctico. Participaron 16 jugadores masculinos de categoría junior, con una edad promedio de 20.6 ± 1.9 años, peso de 84.9 ± 8.4 kg y altura de 183.8 ± 5.1 cm, y una experiencia promedio de 9 ± 2 años en balonmano. Las pruebas de rendimiento incluyeron squat jump (SJ), counter movement jump (CMJ), drop jump (DJ) desde 30 cm y abalakov (ABK) unipodal, utilizando la aplicación "My Jump 2".
Resultados: Los resultados mostraron un aumento significativo en la altura de salto en todas las pruebas (p < .05), con mejoras entre el 12% y 17% en SJ, ABK, CMJ y DJ. La masa corporal varió un 10% entre las evaluaciones inicial y final.
Discusión: Aunque no hubo diferencias significativas en asimetrías iniciales y finales, se observó una reducción en las disparidades de fuerza y potencia tras el programa, mejorando el rendimiento en altura de salto.
Conclusiones: El programa de entrenamiento disminuyó levemente las asimetrías y generó mejoras significativas en la capacidad de salto bipodal en jugadores jóvenes de balonmano.

Palabras clave

Balonmano; Entrenamiento de fuerza; Entrenamiento pliométrico; Prevención de lesiones

Introduction

Handball is a collaborative and oppositional sport in a shared space where most of the determining actions of the game are the result of intense and fast movements (Wagner et al., 2014). The goal of the game is to score goals and in order to achieve this, the handball player must maximize the accuracy and speed of the ball throw (Wagner & Buchecker, 2010). As in various sports, the power capacity is essential and determinant for a good development of the sport gesture (Nikolaidis & Ingebrigtsen, 2013; Valero & Muñoz, 2017) and, in the case of handball, the jump throw is the most frequently applied throwing technique in the game (Wagner & Müller, 2008). On the other hand, the lower body actions vary between accelerations, decelerations, jumps and changes of direction, which are executed mostly at maximum and sub-maximal intensities and with the application of large amounts of force (Gorostiaga et al., 2006; Michalsik et al., 2012; Póvoas et al., 2012). These technical gestures are typical of individual actions that, inserted in a team performance, become key in determining situations of the game.

In light of the above, an analysis is made from the physical demands, handball is a team discipline that involves carrying out maximum intensity and short duration efforts, where athletes have to run, jump and throw the ball, alternating moments of rest or low intensity (Gorostiaga et al., 2006; Granados et al., 2007). Physical capacities such as strength, speed, short and repeated sprint endurance are determinant in the game (Barraza et al., 2015). In addition, in team sports such as handball, the limbs support a significantly asymmetric and high intensity workload due to frequent decelerations in short intervals and constant changes of direction (Spencer et al., 2005; Ahmadabadi et al., 2023).

Consequently, this implies an asymmetric movement mechanism in the lower limbs, resulting in different bilateral force levels (Impellizzeri et al., 2007). On the other hand, it is observed that the rapid muscle contractions of the lower body during the game occur in a closed kinematic chain; that is, the distal and proximal ends of the knee joint maintain a fixed point on which to perform traction (Abernethy et al., 1995). Understanding this mechanics of movement and responding to technical gestures specific to the sport, such as in attack, where feinting, jumping and throwing are crucial, it is there where the dominant limb will absorb a greater mechanical workload than its contralateral limb, while in defense situations the asymmetrical mechanical work decreases and the protagonism is shared between both limbs.

It is for this reason that differences in strength and power values of the lower limbs are related to injuries and decreased sports performances (Bishop et al., 2021; Mainer-Pardos et al., 2024). Based on the above, the objective of this study was to identify asymmetries in the lower limbs and to assess the effect of 12 weeks of unipodal closed chain training on jump height, strength and unipodal power of the lower limbs in young players of the Chilean handball team.

Method

Experimental protocol

This quasi-experimental study applied workloads using strength and power exercises for the lower body. The intervention was developed over twelve weeks, or 12 microcycles (Ahmadabadi et al., 2023), divided into three mesocycles using the ATR (Accumulation, Transmutation and Realization) planning model (Table 1). This approach allowed the identification of three key phases in sports planning (Carazo-Vargas, 2018). Microcycles were planned stepwise with an upward load, leaving the fourth microcycle with a downward curve in volume and intensity that allowed the recovery of the preceding microcycles. Thus, the first training microcycle was called basic microcycle, the second called developmental microcycle, the third called shock microcycle and the fourth called supercompensation microcycle. Workloads were individualized and executed using the (RIR) or Reps in Reserve method, which is based on the possibility of subjectively perceiving how many repetitions can be left in reserve in a series of repetitions already performed. The pause between work series is also determined by the athlete's perception and subject to the subjective perception of the effort.

3 sessions were held per week, distributed on Mondays, Wednesdays and Fridays separated by 48 hours (Ahmadabadi et al., 2023). Each session had a duration of 90 minutes of work and was developed prior to the tactical technical work of the game. Within the total time, a standard warm-up was performed for

all subjects with a duration of 15 minutes, which included the activation and flexibility of the muscle chains involved, in the same way, strength exercises were developed first, followed by the plyometric ones.

Table 1 shows the distribution of loads, volumes and intensities used during 12 weeks.

Table 1. Summary of ATR planning model.

DETAILS	ACCUMULATION				TRANSMUTATION				REALIZATION			
MICROCYCLE NUMBER	1	2	3	4	5	6	7	8	9	10	11	12
MICROCYCLE NAME	B	DP	SHO	SC	B	DP	SHO	SC	B	DP	SHO	SC
% OF INTENSITY	70	75	80	70	80	85	90	85	90	95	100	85
VOLUME IN RIR	r3	r2	r1	r2	r2	r2	r1	r1	r2	r1	r1	r2
VOLUME IN SERIES	3	3	4	3	4	4	5	4	4	4	4	4

B: Basic microcycle; DP: Developmental microcycle; SHO: Shock microcycle; SC: Supercompensation microcycle; RIR: Reps in reserve.

Before and after the 12-week period, unipodal assessments were performed with a battery of 4 jumping tests in the modalities of squat jump (SJ), counter movement jump (CMJ), drop jump (DJ) with 30 cm drop and abalakov (ABK) and a pre and post bipodal test, related to muscle strength and power of the lower limbs.

All players of the junior category of the Chilean national handball team participated in the study; a total of 16 healthy adult men, aged 20.6 ± 1.9 years, weight or body mass 84.9 ± 8.4 kg, and height of 183.8 ± 5.1 cm, with an average of 9 ± 2 years of experience in the sport.

Regarding the experimental protocol, it was approved by the Universidad de Playa Ancha (UPLA) ethics committee in approval act number 010-2022 and followed the recommendations described in the Declaration of Helsinki for human studies (World Medical Association Declaration of Helsinki, 2013). Therefore, after detailed explanation of all procedures and resolution of any doubts, participants signed an informed consent as a prerequisite for their participation in the project.

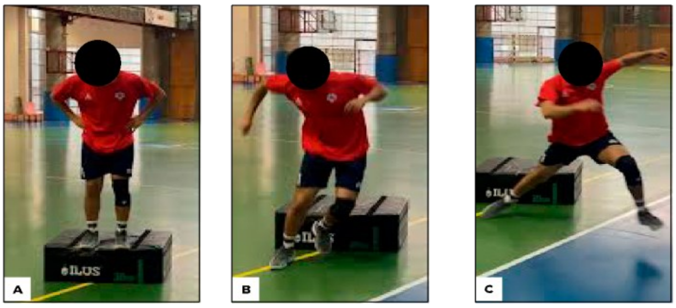
In addition to the above, they provided detailed clarifications and foundations to the group of players, both on the planning and methodologies of training to be developed as well as on the jumping evaluations that would be performed before and after the 12 weeks of physical work contemplated in the research. The evaluation battery and plyometric and strength exercises were widely known by the players, since they had been introduced progressively at early ages, during their training stages (cadets and youth), which contributed to increase the reliability of the evaluations.

The exercises used in the intervention were the following. Power exercises: through exercises with plyometric characteristics (Figure 1 and Figure 2) unipodal drop jump with 30 centimeters (cm) drop with lateral exit to the bilateral opposite side followed by a feint and rejection prior to the throw, (Figure 3) unipodal abalakov with bilateral drop, (Figure 4) unipodal squat jump with bilateral drop, (Figure 5) counter movement jump with bilateral drop and (Figure 6) counter movement jump with unipodal hexagonal bar with bilateral drop. Strength exercises: (Figure 7) Bulgarian lunges, (Figure 8) unipodal leg press, (Figure 9) unipodal 90° box squat, (Figure 10) unipodal gluteal hip thrust and (Figure 11) barbell side squat.

Figure 1. Unipodal drop jump drop from 30 cm with exit to the right. A) Initial position prior to the drop; B) drop and unipodal left foot support; C) lateral exit to the right.

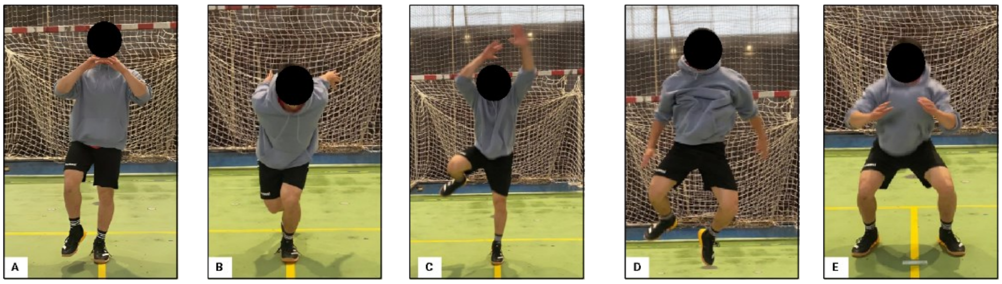
Fuente: Barraza-Gómez et al. (2025).

Figure 2. Unipodal drop jump drop from 30 cm with exit to the left. A) Initial position prior to the drop; B) drop and unipodal right foot support; C) lateral exit to the left.



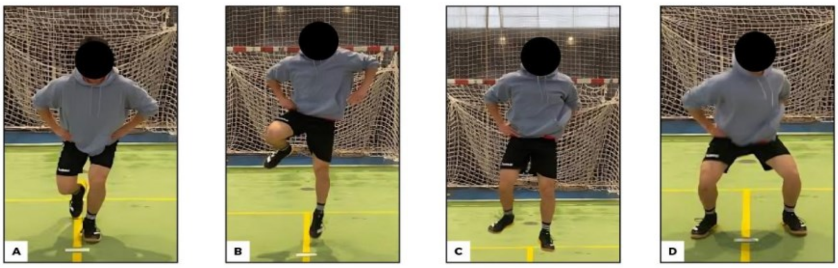
Fuente: Barraza-Gómez et al. (2025).

Figure 3. Unipodal Abalakov. A) Unipodal initial position; B) Eccentric phase descent; C) Concentric phase jump and take-off from the ground; D) Flight phase; E) Bipodal support drop



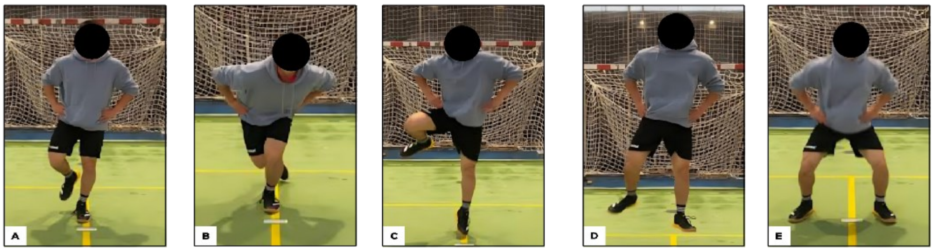
Fuente: Barraza-Gómez et al. (2025).

Figure 4. Unipodal squat jump. A) Unipodal initial position, knee flexion and hands on waist; B) Ascent and take off from the ground in concentric phase; C) Flight phase; D) Bipodal support drop.



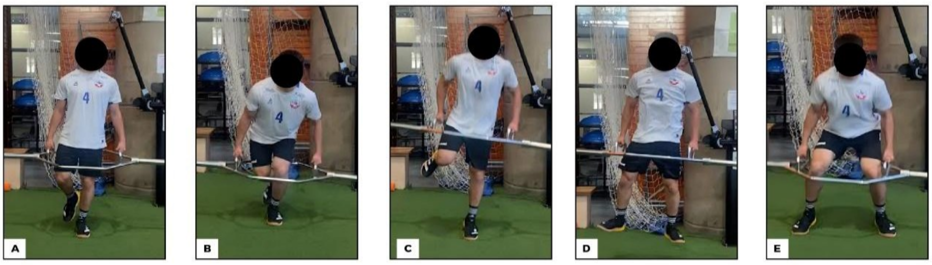
Fuente: Barraza-Gómez et al. (2025).

Figure 5. Unipodal Counter movement jump. A) Unipodal initial position, knee extended; B) Eccentric phase descent; C) Concentric phase ascent; D) Flight phase; E) Bipodal support drop.



Fuente: Barraza-Gómez et al. (2025).

Figure 6. Counter movement jump with unipodal hexagonal bar. A) Unipodal initial position, knee extended; B) Eccentric phase descent; C) Concentric phase ascent; D) Flight phase; E) Bipodal support drop.

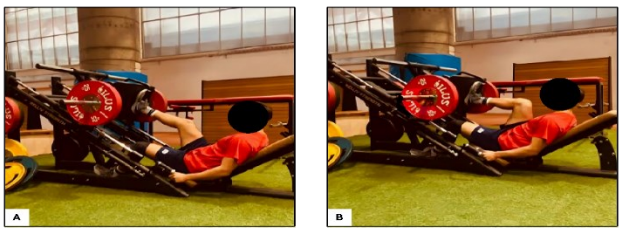


Fuente: Barraza-Gómez et al. (2025).

Figure 7. Bulgarian lunge with unilateral unipodal dumbbell. A) Unipodal initial position; B) Eccentric phase descent.

Fuente: Barraza-Gómez et al. (2025).

Figure 8. Unipodal press. A) Concentric phase; B) Eccentric phase.

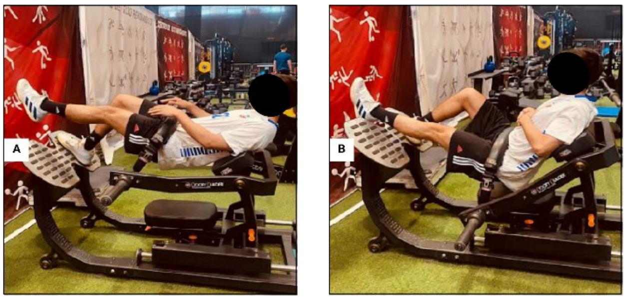


Fuente: Barraza-Gómez et al. (2025).

Figure 9. Unipodal squat to the 90° box. Unipodal support for subsequent ascent to the box.

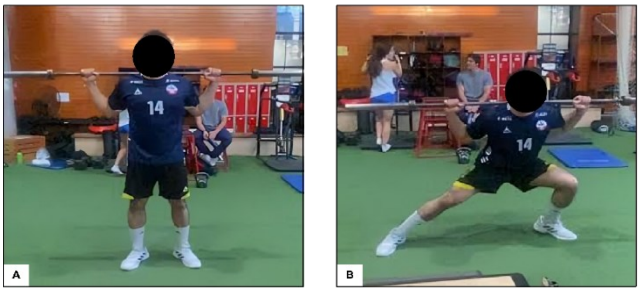
Fuente: Barraza-Gómez et al. (2025).

Figure 10. Gluteus unipodal hip thrust. A) Unipodal initial position, hip extension phase; B) eccentric hip flexion phase.



Fuente: Barraza-Gómez et al. (2025).

Figure 11. Barbell lateral squat. A) Bipodal initial position; B) Lateral displacement and descent eccentric phase.



Fuente: Barraza-Gómez et al. (2025).

The sets of exercises were distributed in 3 weekly sessions separated by 48 hours, always at the beginning of the session; first the strength exercises followed by plyometric exercises with transfer to Handball, all after 15 minutes of warm-up, which included cycling for 5 minutes, activation of the middle zone and lower body together with ballistic joint flexibility for 10 minutes. The recovery or pause time between sets was in relation to the effort perception, that is to say that the player performs a new set when he/she perceives his/her recovery to be complete. This was approximately 3 to 5 minutes.

Assessment protocol

Basic anthropometric assessments were performed, where the measurement protocol standardized by the International Society for the Advancement of Kinanthropometry (ISAK) (Stewart et al., 2011) was applied. The general anthropometric data collected corresponded to body mass and height. Body mass was obtained with an electronic scale, with 20 g sensitivity, Jadever (JWI 3000®, Taiwan). Height was assessed with a Seca 213 stadiometer (Seca, Germany).

To assess the unipodal strength and power of lower limbs, the iPhone 11 camera was used together with the "My Jump 2" mobile application. This tool allows measuring different types of vertical jumps in a simple, reliable and scientifically validated way (Balsalobre-Fernández et al., 2015; Haynes et al., 2019; Stanton et al., 2015). The application employs the high-speed camera to record on video the tests performed by the athletes. Thanks to a frame-by-frame system, the take-off moment and the contact moment on landing are precisely identified, and the subject's body weight (in kg) is entered to obtain accurate calculations. The application provides various values, including jump height (in centimeters), flight time (in meters per second), contact time, applied force (in newtons) and the asymmetry index of the lower limbs.

Before the formal evaluation, a familiarization process was also carried out with each participant, although, as mentioned above, the assessments were known by the athletes who had performed them in previous stages of their sports training. This process consisted of 5 sessions in which the athletes were trained in the technique of each type of jump to be executed as part of the training plan and likewise for the jumps used as an evaluation method, they were also introduced to the use of the application, ensuring that they understood how to execute the jump accurately and consistently. In addition, test recordings were made to familiarize participants with the take-off and landing moments, thus optimizing the accuracy of the assessment. It is important to highlight that the My Jump 2 application can be used by both trained and untrained evaluators, as both groups are able to make similar observations at the key moments of the test (Gallardo-Fuentes et al., 2016; Peng et al., 2024).

Subjects were evaluated before and after the 12 weeks of intervention, on two consecutive days during the afternoon. The order of the evaluations was as follows: SJ, DJ, CMJ and ABK. The best of three attempts was recorded for each test. During the assessment sessions, 3 to 5 players were called in each turn, who performed three consecutive attempts in each test, with the highest value being recorded. Between attempts, the players had a break of 15 to 20 seconds, and between tests they had a rest of 7 to 10 minutes. During the breaks, the players were hydrated and rested while seated, and before each new test they performed joint mobility exercises and ballistic stretching.

Likewise, during the days prior to the evaluations, the participants were instructed to sleep at least 8 hours, to avoid additional physical exercise on the day of the test and to abstain from consuming food up to 4 hours beforehand, as well as from ingesting stimulant beverages or coffee. In the week prior to the evaluations, the physical and technical training load was reduced from 5 to 3 sessions per week, also reducing the volume and intensity of each session, with a maximum duration of 45 minutes. Likewise, during the 24 hours prior to the tests, no exercises involving the lower body were performed, prioritizing regenerative activities.

Calculation of asymmetry

Asymmetry was calculated as the percentage difference between the right limb (RL) and the left limb (LL) (Knapik et al., 1991; Guan et al., 2022)

Equation = ((RL – LL) / LL) *100)

For the percentage difference between the right and left unipodal limb:

(RL/LL) −1) × 100=Percentage Difference %

For the percentage difference between the pre and post bipodal evaluation:

(PRE/POST−1) × 100=Percentage Difference %

Statistical analysis

SPSS software version 22.0 was used for data analysis. The normality of the distribution of the weight and jumping variables was assessed using the Shapiro–Wilk test. Data are presented using descriptive measures, including mean, standard deviation, and are organized in table format.

Differences between pre - and post-intervention assessments were analyzed using the Student's t-test for related samples, with a statistical significance level set at $p < .05$.

Below are images of the unipodal power and strength exercises worked for 12 weeks.

Results

The results are presented below in tables summarizing the main data. Table 2. Differences in jumping tests (mean ± SD) in the variables of height (cm), strength (N) and power (W) unipodal left and right limb in the pre-subjects evaluation.

Table 2. Left and right unipodal jumping PRE evaluation.

	LEFT		RIGHT				
SJ	X̄	SD	X̄	SD	P < .05	Δ%	Comp*
JUMP HEIGHT (cm)	20.9	3.2	20.6	4.2	.76	2%	R < L
STRENGTH (N)	2408.5	167.2	2387.5	193.4	.52	1%	R < L
POWER (W)	2438.5	321.9	2407.9	436.8	.77	1%	R < L
ABK							
JUMP HEIGHT (cm)	28.4	4.2	28.3	4.5	.13	0%	R = L
STRENGTH (N)	2656.7	252.0	2667.9	249.7	.82	0%	R = L
POWER (W)	2956.0	855.4	3101.5	478.0	.49	5%	R > L
CMJ							
JUMP HEIGHT (cm)	23.2	4.4	24.6	5.6	.22	6%	R > L
STRENGTH (N)	2499.7	259.1	2595.5	300.0	.17	4%	R > L
POWER (W)	2680.7	524.5	2804.1	624.4	.24	5%	R > L
DJ							
JUMP HEIGHT (cm)	27.3	5.3	26.2	5.4	.29	4%	R < L
CONTACT TIME (ms)	338.6	71.9	328.6	105.9	.60	3%	R < L

SJ: Squat jump; ABK: Abalakov jump; CMJ: Counter movement jump: DJ: Drop jump; ms: millisecond; cm: centimeters; N: Newton; W: Watts; X̄: mean; SD: Standard deviation; Δ%: Initial percentage difference between right and left; Comp*: Right side over left side; *:p< .05: significance

Table 2 shows that although there are asymmetries in the lower limbs in the pre-evaluation, these were not significant, indicating a $P > .05$.

Likewise, percentage variations were found in strength, power and jump height between 2% and 6%.

Table 3. Differences in jumping tests, height (cm), strength (N) and power (W) unipodal right and left limb variables in the post evaluation of all jumping variables (mean ± SD) of the subjects.

Table 3. Left and right unipodal jumping POST evaluation.

	LEFT		RIGHT				
SJ	X̄	SD	X̄	SD	P < .05	Δ%	Comp*
JUMP HEIGHT (cm)	23.5	3.6	23.5	5.3	.97	0%	R = L
STRENGTH (N)	2519.8	188.5	2538.4	184.2	.45	1%	R > L
POWER (W)	2670.0	351.8	2689.5	351.8	.77	1%	R > L
ABK							
JUMP HEIGHT (cm)	30.8	4.7	31.0	4.3	.85	1%	R > L
STRENGTH (N)	2762.2	225.0	2681.9	314.0	.27	2%	R < L
POWER (W)	3396.7	485.5	3401.9	491.8	.96	0%	R = L
CMJ							
JUMP HEIGHT (cm)	26.2	4.3	26.5	5.4	.76	1%	R > L
STRENGTH (N)	2612.3	225.3	2636.4	309.1	.61	1%	R > L
POWER (W)	2948.2	460.3	2974.8	593.7	.79	1%	R > L
DJ							

JUMP HEIGHT (cm)	30.5	4.5	30.9	4.7	.63	1%	R > L
CONTACT TIME (ms)	363.4	53.4	367.9	83.1	.75	1%	R > L

SJ: Squat jump; ABK: Abalakov jump; CMJ: Counter movement jump: DJ: Drop jump; ms: millisecond; cm: centimeters; N: Newton; W: Watts; X̄: mean; SD: Standard deviation; Δ%: final percentage difference between right and left; Comp*: Right side over left side; *: p< .05: significance.

Table 3 shows that although there are asymmetries in the lower limbs, these were not significant (P > .05). A percentage decrease in the differences between the left and right limbs was also observed in relation to the pre-evaluation, values that decreased between 0% and 2%.

Table 4. Differences in Bipodal jumping tests, height variables (cm), pre and post evaluation of all jumping variables (mean ± SD) of the subjects.

Table 4. Bipodal jumping pre and post evaluation.

	PRE		POST			
	X̄	SD	X̄	SD	P < .05	Δ%
SJ JUMP HEIGHT (cm)	28.1	3.7	33.0	3.3	.00*	17%
ABK JUMP HEIGHT (cm)	41.6	5.5	46.5	6.1	.00*	12%
CMJ JUMP HEIGHT (cm)	34.3	4.7	39.4	6.4	.00*	15%
DJ JUMP HEIGHT (cm)	40.0	6.1	46.6	6.2	.00*	17%
CONTACT TIME (ms)	286.9	72.7	306.0	76.9	.30	7%

SJ: Squat jump; ABK: Abalakov jump; CMJ: Counter movement jump: DJ: Drop jump; ms: millisecond; cm: centimeters; X̄: mean SD: Standard deviation; Δ%: Initial and final percentage difference; p<.05: significance

Table 4 shows significant increases (p < .05) in the performance of jumping tests, this in the variables of height (cm), SJ, ABK, CMJ and DJ modalities. Increases between 12% and 17% were presented. As for the contact time in DJ, this increase was not significant (p=0.03), indicating that the subjects took longer to take off from the ground, generating higher levels of strength applied to the floor.

Discussion

The objective of this research was to identify asymmetry levels of the lower limbs and the effect of applying a plyometric and unipodal strength work plan for 12 weeks in the lower limbs.

As for the asymmetries between the left and right limbs, in the evaluation prior to the beginning of the unipodal load applications, they were not significant (p > .05). Values of between 2% and 6% difference were found in jump height (cm), SJ, CMJ and DJ, but not in ABK, where there was 0% asymmetry. The data found in this research are consistent with the differences reported between limbs for the CMJ jump: 10.4% (Lockie et al., 2014), and 5% to 6% asymmetry in vertical jump among collegiate athletes (Dos'Santos et al., 2019). In handball, studies on adolescent male players have reported values ranging between 8% and 11% (Madruga-Parera et al., 2019). According to research, bilateral asymmetries exceeding 10% are generally associated with an increased risk of injuries and muscle pathologies (Croisier et al., 2002; Vargas et al., 2020; Bishop et al., 2018).

On the other hand, it is necessary to consider that asymmetries have been identified that cause a decrease in the sports performance, as indicated by Bishop et al., (2021) who reported that asymmetries in jump height of 12.5% in the unipodal CMJ evaluation were associated with a lower performance in the 5 m (r = .49; p < .05), 10 m (r = .52; p < .05) and 20 m (r = .59; p < .01) sprint. Similarly, negative correlations have been found between jumping ability and time in 10- to 20-meter tests, indicating that lower jump height, strength, and power were associated with longer times over these distances (Lockie et al., 2011; McCurdy et al., 2010; Meylan et al., 2009). Bishop et al. (2021) stated that asymmetries identified in vertical jump were related to longer times in speed tests and that in triple jump tests, they were associated with lower horizontal and vertical jump performance. Therefore, it is relevant not only to identify these differences in limb capacities to optimize sports performance, but also as a means to prevent injuries that may hinder the proper development of training, as well as to reduce the time and frequency of physical work sessions and competition (Hewit et al., 2012; Impellizzeri et al., 2007; Menzel et al., 2013).

Regarding the asymmetries observed in the subsequent evaluation, differences similar to those found in the previous evaluation were identified; however, these asymmetries were not significant and remained below 10%, which is considered irrelevant (Vargas et al., 2020). Plyometric and strength work for the lower limbs helped to reduce the non-significant differences in jump height, strength and power, achieving values between 0% and 1% in jump height (in cm), specifically: SJ 0%, ABK 1%, CMJ 1% and DJ 1%. The above has been identified that performing these four jumping variants as specific tests, representative of the characteristics of the game, allows identifying with greater precision the individual asymmetries that are common in players. In addition, these tests consider factors such as balance, coordination, physical capacity and playing position of handball players, which facilitates the implementation of specific interventions in the microcycles of strength and power work (Cadens-Roca et al., 2023).

On the other hand, when considering the pre and post bipodal evaluations in the jumping variables (SJ, ABK, CMJ and DJ), significant differences were found in all of them, with improvements in the jump height achieved ($p = .00$), representing increases between 12% and 17%. This is particularly relevant, since in elite athletes the jump height achieved is closely correlated with explosive muscular strength (Bosco & Komi, 1979; Viitasalo & Bosco, 1982). Likewise, jump height shows a direct relationship with speed, muscle power, coordination and agility (Liebermann & Katz, 2003; Patterson & Peterson, 2004; Wisløff et al., 2004). In a study conducted on 8 handball players aged 17 from Santander, Spain, the average jump values obtained were SJ 31.76 ± 4.10 cm, CMJ 34.51 ± 5.07 cm, and ABK 41.41 ± 5.46 cm (Acevedo Mindiola et al., 2020). These values were slightly lower than those found in our research. Other results from a study with 34 adult handball players reported average jump values of SJ 34.10 ± 6.10 cm, CMJ 36.6 ± 6.22 cm, and ABK 43.45 ± 6.46 cm (Massuça & Fragoso, 2013). In 26 Spanish players aged between 17 and 20 years, average values of SJ 28.99 ± 6.03 cm, CMJ 32.12 ± 6.93 cm, and ABK 37.58 ± 5.85 cm were found (Sebastiá Amat et al., 2017), which were lower than those obtained in our study after the 12-week plyometric training period." These improvements were the result of the application of a plyometric and closed kinetic chain strength work protocol, performed unipodally for the lower limbs within the ATR planning, which made it possible to compensate for the differences between limbs. This type of exercise is preferable to open kinetic chain exercises to improve strength and speed in the limbs, since they are considered more specific, functional and applied to competitive sports activity (Cordova & Armstrong, 1996; Goranovic et al., 2023).

Similarly, this strength and plyometric training protocol led to improvements in bipodal jump height after 12 weeks of intervention, which is consistent with the findings reported by Goranovic et al. (2023). Natural asymmetries in athletes stem from brain dominance, either homolateral or contralateral, over skeletal musculature; however, these can be accentuated due to years of practice in high competition. In general, athletes tend to predominantly use their dominant side when jumping and throwing, which contributes to these imbalances in unilateral physical capacity (Hewit et al., 2012). On the other hand, by reducing these asymmetries, applying force to the floor in a bipodal manner allows for a more balanced distribution of body weight, optimizing the jumping phase by employing the strength of both limbs more equally, which is especially useful in defensive situations during the game. Also, bilateral asymmetries can have negative effects on both running speed and jumping ability (Fort-Vanmeerhaeghe et al., 2020).

Conclusions

In the selected junior handball players from Chile, mild but not significant asymmetries were found, which is beneficial for sports performance. However, it is suggested to perform periodic tests for bilateral asymmetries to ensure that training does not increase the imbalances between the lower limbs; in case they are detected, it is recommended to implement specific interventions in the training program to reduce them. In addition, the physical work program with plyometric and unipodal strength exercises, applied for 12 weeks with 3 weekly sessions of 90 minutes at the beginning of the technical-tactical training and following the ATR planning model, managed to reduce these slight asymmetries, correcting them almost in their entirety. Lastly, consider that the single-leg training program led to significant improvements in the two-leg jumping ability.

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