

PERFORMANCE OF BRAZILIAN UNIVERSITY HANDBALL PLAYERS IN THE VERTICAL JUMP AFTER MAXIMUM STRENGTH TRAINING

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Abstract

This study aimed to analyze the performance of the vertical jump with counter movement (CMJ), in university handball athletes, immediately after the maximum strength training in multiple series and after 10 and 15min of rest. Twelve male athletes participated, age 20.9 ± 2.4 years old, height 1.78 ± 0.05 m and Body Mass Index (BMI) 28.74 ± 8.1 kg/m². After the tests and retests of 1 repetition maximum (1RM) for the dominant and non-dominant sides, in the leg extension, the volunteers performed crossover after 48 hours of the training sessions. CMJ measurements were collected before and immediately after each training protocol and after 10 and 15min of rest. Passive recovery between sets was three minutes. The intervals between training protocols were at least 45min. There were no statistical differences for the CMJ between the moments pre-, post-training session, 10 and 15min of rest in the different protocols, but progressive increases in the CMJ variables were observed, extending up to the 15th minute of rest, in all training protocols when comparing the results of the means of the CMJ variables of the moments post-training session, 10 and 15min of rest with the averages of the variables from the pre-training session, being more evident in the alternate unilateral protocol, which, unlike the other protocols of the study, performed series with the two lower limbs. It was evidenced that the training protocols of short duration and with high dynamic efforts, previously performed, influenced the performance of the CMJ, favoring for the transient improvement of the explosive muscular strength of the athletes.

Keywords: Elastic Energy. Muscle Strength. Physical Exercise. Post-Activation Potentiation. Sports.

1. Introduction

Handball is a highly demanding sport, which requires several complex motor gestures, requires athletes to perform intermittent efforts, involving frequent body contact, several displacements at different speeds, high intensity, and strength actions (Hermassi et al. 2018). It combines creativity and motor skills to make passes and dribbling, changes in rhythms and directions, jumps and throws, spins, and blocks (Schwesig et al. 2017). In conjunction with technical and tactical training, to maximize physical conditioning

and specific sports performance of handball players, exercises should be included in the training sessions to develop greater resistance to intermittent high-intensity and short-term efforts, as well as improving agility, speed, strength, and power (Hermassi et al. 2010; Hermassi et al. 2011; Dello Iacono et al. 2016).

The increase in muscle strength and power is very desired and necessary in the most diverse sports, causing different training sessions to be inserted in the athletes' periodization. Among the models, the combination of resistance training (RT) and plyometric is effective in promoting and improving results for the vertical jump (Perez-Gomez and Calbet 2013), one of the essential motor valences for some sports, having research that used the vertical jump as a test to dimension the performance of athletes (Dal Pupo et al. 2014; Dobbs et al. 2015).

The optimization for better results causes in the sports environment a constant search for more effective and efficient training methods. A strategy used for the acute improvement of the performance of the jump is the post-activation potentiation (PAP), which comprises in the transient increase of the capacity of production of muscular power observed after the accomplishment of the RT with exercises of maximum or near voluntary stimuli (Ebben 2006; Dello Iacono and Seitz 2018).

However, the relationship between the resting time and the jumping training periods is one of the factors that need to be considered, since the sum of repeated executions, in sessions with short recovery periods, can negatively affect the explosive muscle strength, reducing the vertical jump performance (Longoria et al. 2015). Also, the wrong planning and poor implementation of the previous physical effort activity (conditioning activity) can generate fatigue, which would hinder the appearance of PAP (Tsolakis et al. 2011).

Thus, investigations on the performance of the vertical jump and the recovery time after different training sessions become necessary for a better understanding of the relationship between these variables. In this sense, the present study aims to analyze, in university handball athletes, the performance in the vertical jump before, immediately after the maximum strength training in multiple series, and after 10 and 15 minutes of rest.

2. Material and Methods

Design

This study can be classified as an original study (Thomas et al. 2012).

Participants

The sample consisted of 12 male handball athletes volunteers from a university team in the West Zone of Rio de Janeiro, age 20.9 ± 2.4 years old, height 1.78 ± 0.05 m and BMI 28.7 ± 8.1 kg/m², which met the inclusion criteria: a) right-handed lower limbs; b) athletes of the referred sport for more than 18 months; c) resistance training practitioners with at least one year of experience and a minimum weekly frequency of three days; d) those who responded negatively to the Physical Activity Readiness Questionnaire (PAR-Q) (ACSM 2014). All those who used ergogenic substances and/or those who presented injuries or limitations that made it impossible to perform the programmed exercises were excluded.

Research ethics

All participants were informed about the training protocols and according to the Declaration of Helsinki (WMA 2013) and the one determined by Resolution 466/2012 of the National Health Council (Brasil 2013), on research with human beings, voluntarily signed the Informed Consent Form (ICF), making it clear that the data would only be used by the researchers, keeping the collected information confidential.

Procedures

Data collection took place as follows: each volunteer, always at the same time, made three visits with an interval between them of at least 48 hours. On the 1st visit, the guests answered the PAR-Q questionnaire. Those who met the inclusion criteria were elucidated about all data collection procedures and study

intervention; signed the informed consent form, performed anthropometric measurements and the tests of 1 repetition maximum (1RM) in the leg extension unilaterally to the dominant (right) and non-dominant (left) sides. On the 2nd visit, the athletes underwent 1RM retests. On the 3rd visit, the participants performed the three training sessions alternately in the crossover, called: Alternate Unilateral Protocol (AltUniP), 50% of the participants started the training session with the right lower limb and the rest with the left; Unilateral Dominant Side Protocol (UniDSP); Unilateral Non-Dominant Side Protocol (UniNdSP). Measures of vertical jumps with counter movement were collected before and immediately after each protocol and after 10 and 15 minutes of rest (figure 1).

All tests, retests and training protocols were performed in a place with controlled room temperature between 18 and 22° C and on days and times similar to those of the athletes' training. So that the results were not influenced, the study participants were instructed not to perform physical exercises of any kind and not to ingest stimulant substances in the 24 hours prior to data collection and intervention.

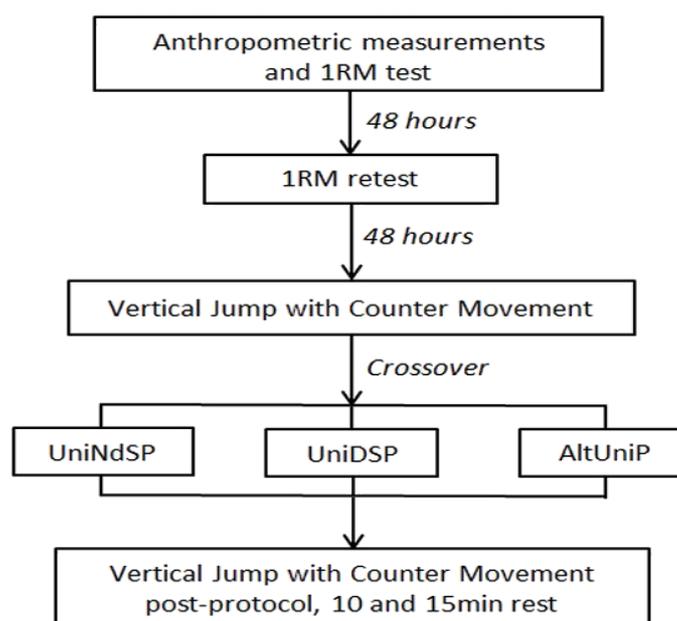


Figure 1. Schematic model of the study. 1RM: 1 repetition maximum; UniNdSP: Unilateral Non-Dominant Side Protocol; UniDSP: Unilateral Dominant Side Protocol; AltUniP: Alternate Unilateral Protocol.

Anthropometric measurements

To characterize the sample, anthropometric measurements followed the specific protocols suggested by the International Standards for Anthropometric Assessment (ISAK) (Stewart et al. 2011). Height was established using a Cardiomed stadiometer (model WCS, Brazil), with a maximum capacity of 2.20m and an accuracy of 0.001m. A bioimpedance scale (BIA), brand OMRON® (Full Body Sensor, model HBF-514C, USA) (Bosy-Westphal et al. 2008), with 100g precision and 150kg limitation for both genders aged between 18 and 80 years old, was used to determine the total body mass (TBM); percentage of fat (%F); percentage of skeletal muscle (%SM); body mass index (BMI); and basal metabolic rate (BMR).

Test of 1 repetition maximum (1RM)

For the verification of training overload and exercise prescription criteria, it was decided to apply the 1RM test, following Brown's recommendations (Brown 2017). The exercises with the lower limbs were performed in a unilateral way, in accordance with Della Corte's procedures (Della Corte et al. 2020a). Tests were interrupted when participants failed to perform the complete and/or correct movement in the programmed exercise, resulting in voluntary concentric failure (Della Corte et al. 2018).

Vertical jump with counter movement (CMJ)

The vertical impulse test was performed with the MyJump2 App (Gallardo-Fuentes et al. 2016; Haynes et al. 2019) application, developed for Apple® devices, which presents reliable and validated features for a vertical jump with counter movement (CMJ) measurement.

MyJump2 analyzes jumps with counter movement from the video capture, the researchers identifying the takeoff and landing frames manage to obtain the calculation of the maximum height of the CMJ in centimeters (cm) using the application's algorithms (Bosco et al. 1983; Samozino et al. 2008), the flight time of the CMJ in milliseconds (ms), the velocity of the CMJ in meters per second (m/s), the force of the CMJ in newtons (N) and the peak power of the CMJ in watts (W).

Alternate unilateral protocol (AltUniP)

The training protocol (AltUniP) consisted of alternating unilateral execution of the lower limbs, with no recovery interval between the dominant (right) and non-dominant (left) sides, of an exercise session composed of five series of repetition maximums in the leg extension with overloads for 90% of 1RM (Kraemer and Ratamess 2004).

Unilateral dominant side protocol (UniDSP)

The training protocol (UniDSP) consisted of the unilateral execution of the right lower limb, dominant side, of an exercise session composed of five series of repetition maximums in the leg extension with overloads for 90% of 1RM (Kraemer and Ratamess 2004).

Unilateral non-dominant side protocol (UniNdSP)

The training protocol (UniNdSP) consisted of the unilateral execution of the left lower limb, non-dominant side, of an exercise session composed of five series of repetition maximums in the leg extension with overloads for 90% of 1RM (Kraemer and Ratamess 2004).

Training session

The participants underwent training sessions on the lower limbs, which consisted initially of a specific warm-up (Souza et al. 2020) of a series of 12 repetitions in the leg extension with an overload of 60% of 1RM. Two minutes after the warm-up, training protocols were performed through the alternate crossover entry, which was performed on the same day with a minimum interval of 45 minutes between them.

The videos for analysis of the CMJ were obtained in the moments before, after the training session, 10 and 15 minutes of rest, the evaluators positioned themselves in the frontal plane at a maximum distance of 150 cm from the subject with the camera positioned at the feet of the participant. At the command of the appraisers, the appraiser with his hands on his waist, squats, jumps, and lands on the ground, the appraisers selected the images of the jump counting from the moment when the appraisee's feet left the ground until they touched the ground (Balsalobre-Fernández et al. 2015).

Statistical analysis

The data were processed using the Statistical Package for Social Sciences software (SPSS 22.0 - Chicago, IL, USA) and presented by means of descriptive analysis of mean, standard deviation and minimum, and maximum values. The normality and homogeneity of the sample data were verified with the Shapiro-Wilk and Levene tests, respectively. To analyze the differences between training protocols, the paired t-Student test and the effect size Cohen's were applied. To check the performance of the jump after the training sessions, ANOVA one-way was applied, followed by Bonferroni's post hoc. The level of significance was set at $p < 0.05$.

3. Results

Table 1 shows the data on the participants' body composition, presented by the mean, standard deviation, minimum and maximum.

Table 1. Descriptive statistics of the Body Composition of 12 male handball athletes from a university team, Rio de Janeiro, Brazil, 2019.

	Age (years)	Height (m)	TBM (kg)	%F	FM (kg)	%SM	SMM (kg)	BMI (kg/m ²)	BMR (kcal)
Mean	20.9	1.78	91.3	29.4	29.7	33.0	28.6	28.74	1800.5
Standard deviation	2.4	0.05	26.7	12.5	20.3	6.8	3.4	8.1	292.1
Mínimum	18	1.71	64.1	14.5	9.3	23.6	25.6	20.69	1550
Máximum	26	1.85	146.0	48.6	71.0	44.7	34.6	46.60	2403

TBM: total body mass; % F: percentage of fat; FM: fat mass; % SM: percentage of skeletal muscle; SMM: skeletal muscle mass; BMI: body mass index; BMR: basal metabolic rate.

Table 2 shows the data regarding the training sessions of the participants, presented by the mean, standard deviation and paired t-Student test for the dependent samples.

Table 2. Results of Training Sessions performed by 12 male handball athletes from a university team, Rio de Janeiro, Brazil, 2019.

	UniDSP				AltUniP (Dominant Side)			
	90% of 1RM (kg)	Total RM	TTV (kg)	RPE (0 to 10)	90% of 1RM (kg)	Total RM	TTV (kg)	RPE (0 to 10)
Mean	54.2	16.8	918.3	8.8	54.2	18.9	1028.4	8.1
SD	12.9	3.2	321.1	1.3	12.9	2.7	312.5	1.1
	UniNdSP				AltUniP (Non-Dominant Side)			
	90% of 1RM (kg)	Total RM	TTV (kg)	RPE (0 to 10)	90% of 1RM (kg)	Total RM	TTV (kg)	RPE (0 to 10)
Mean	50.8	14.9	757.0	9.4	50.8	17.5	887.6	8.6
SD	12.2	2.7	251.7	0.8	12.2	2.8	260.3	1.1
<i>t</i> (p-value)	<0.001*	0.041*	0.009*	0.067	<0.001#	0.012#	0.002#	0.026#
Cohen's <i>d</i>	0.270	0.641	0.559	0.555	0.270	0.509	0.489	0.454
	UniDSP				UniNdSP			
	90% of 1RM (kg)	Total RM	TTV (kg)	RPE (0 to 10)	90% of 1RM (kg)	Total RM	TTV (kg)	RPE (0 to 10)
Mean	54.2	16.8	918.3	8.8	50.8	14.9	757.0	9.4
SD	12.9	3.2	321.1	1.3	12.2	2.7	251.7	0.8
	AltUniP (Dominant Side)				AltUniP (Non-Dominant Side)			
	90% of 1RM (kg)	Total RM	TTV (kg)	RPE (0 to 10)	90% of 1RM (kg)	Total RM	TTV (kg)	RPE (0 to 10)
Mean	54.2	18.9	1028.4	8.1	50.8	17.5	887.6	8.6
SD	12.9	2.7	312.5	1.1	12.2	2.8	260.3	1.1
<i>t</i> (p-value)	1.000	0.079	0.082	0.043 [‡]	1.000	0.029 [†]	0.024 [†]	0.017 [†]
Cohen's <i>d</i>	0.0	0.709	0.342	0.581	0.0	0.945	0.510	0.831

UniDSP: Unilateral Dominant Side Protocol; AltUniP: Alternate Unilateral Protocol; UniNdSP: Unilateral Non-Dominant Side Protocol; 90% of 1RM: training overload; Total RM: total of repetition maximums (series x repetitions); TTV: total training volume (exercises x overload x series x repetitions); RPE: rating of perceived exertion; SD: standard deviation; *t* (p-value): paired t-Student test; Cohen's *d*: effect size; *: Significant difference between UniDSP and UniNdSP; #: Significant difference between AltUniP (dominant side) and AltUniP (non-dominant side); Subtitle. [‡]: Significant difference between UniDSP and AltUniP (dominant side); [†]: Significant difference between UniNdSP and AltUniP (non-dominant side).

It was observed that between UniDSP and UniNdSP the values of the variables 90% of 1RM ($t = 5.583$; $p < 0.05$), Total RM ($t = 2.309$; $p < 0.05$) and TTV ($t = 3.137$; $p < 0.05$) of UniDSP were significantly higher than UniNdSP, but there was no significant difference in RPE.

Between the dominant and non-dominant side of AltUniP, it was observed that the values of the variables 90% of 1RM ($t = 5.583$; $p < 0.05$), Total RM ($t = 3.027$; $p < 0.05$) and TTV ($t = 4.190$; $p < 0.05$) of AltUniP (dominant side) were significantly higher and the RPE ($t = 2.569$; $p < 0.05$) significantly lower.

When comparing the results between UniDSP and AltUniP (dominant side), it was observed that there was only a significant difference in RPE ($t = 2.283$; $p < 0.05$) with a decrease in AltUniP (dominant side).

Regarding the results compared between UniNdSP and AltUniP (non-dominant side), it was observed that the values of the variables Total RM ($t = 2.500$; $p < 0.05$) and TTV ($t = 2.609$; $p < 0.05$) of the AltUniP (non-dominant side) were significantly higher and RPE ($t = 2.803$; $p < 0.05$) significantly lower.

Figure 2 (A, B, C, D and E) shows the data regarding the performance of the vertical jump with counter movement performed by 12 male handball athletes from a university team, Rio de Janeiro, Brazil, 2019, analyzed by ANOVA one-way.

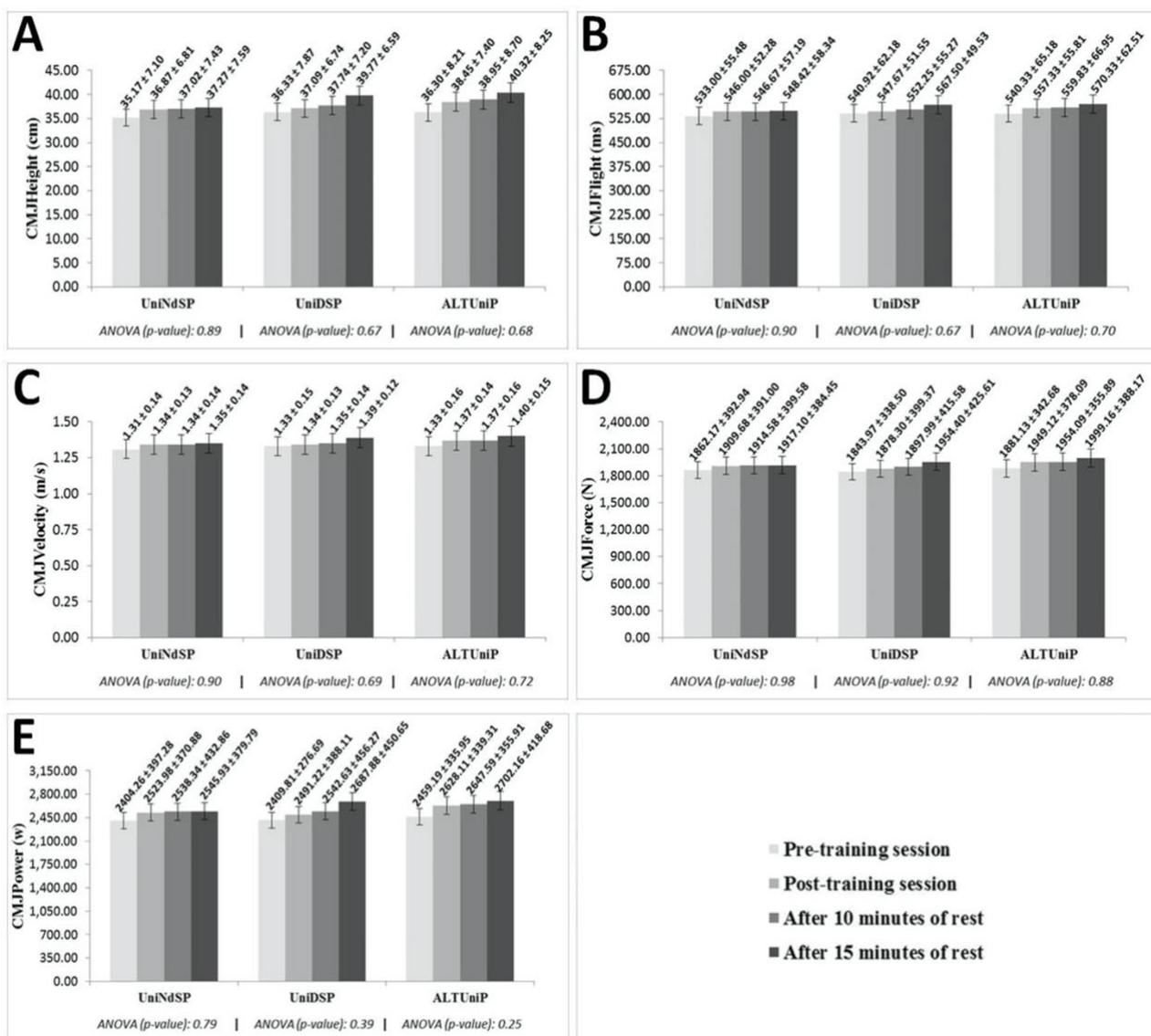


Figure 2. A – graphs with the results of the maximum height (CMJHeight) of the Vertical Jump with Counter Movement (CMJ) after all training protocols. UniNdSP: Unilateral Non-Dominant Side Protocol; UniDSP: Unilateral Dominant Side Protocol; AltUniP: Alternate Unilateral Protocol. B – graphs with the results of the flight time (CMJFlight) of the Vertical Jump with Counter Movement (CMJ) after all training protocols. UniNdSP: Unilateral Non-Dominant Side Protocol; UniDSP: Unilateral Dominant Side Protocol; AltUniP: Alternate Unilateral Protocol. C – graphs with the results of the velocity (CMJVelocity) of the Vertical Jump with Counter Movement (CMJ) after all training protocols. UniNdSP: Unilateral Non-Dominant Side

Protocol; UniDSP: Unilateral Dominant Side Protocol; AltUniP: Alternate Unilateral Protocol. D – graphs with the results of the force (CMJForce) of the Vertical Jump with Counter Movement (CMJ) after all training protocols. UniNdSP: Unilateral Non-Dominant Side Protocol; UniDSP: Unilateral Dominant Side Protocol; AltUniP: Alternate Unilateral Protocol. E – graphs with the results of the peak power (CMJPower) of the Vertical Jump with Counter Movement (CMJ) after all training protocols. UniNdSP: Unilateral Non-Dominant Side Protocol; UniDSP: Unilateral Dominant Side Protocol; AltUniP: Alternate Unilateral Protocol.

There were no significant differences in the CMJ variables between the moments pre-, post-training session, 10 and 15 minutes of rest, after all training protocols.

Table 3 shows the differences and respective percentages of the results of the means of the CMJ variables of the moments post-training session, 10 and 15 minutes of rest with the means of the variables of the pre-training moment.

Table 3. Difference between the moments of Vertical Jump with Counter Movement (CMJ), performed by the 12 male handball athletes from a university team, Rio de Janeiro, Brazil, 2019.

	UniNdSP			UniDSP			AltUniP		
	Post	10min	15min	Post	10min	15min	Post	10min	15min
CMJHeight (cm)	1.69	1.85	2.09	0.76	1.41	3.44	2.15	2.65	4.02
CMJHeight (%)	4.82	5.25	5.95	2.10	3.88	9.47	5.92	7.29	11.07
CMJFlight (ms)	13.00	13.67	15.42	6.75	11.33	26.58	17.00	19.50	30.00
CMJFlight (%)	2.44	2.56	2.89	1.25	2.10	4.91	3.15	3.61	5.55
CMJVelocity (m/s)	0.03	0.03	0.04	0.02	0.03	0.06	0.04	0.05	0.07
CMJVelocity (%)	2.36	2.55	2.87	1.26	2.07	4.84	3.08	3.52	5.41
CMJForce (N)	47.52	52.42	54.93	34.32	54.02	110.42	67.99	72.96	118.03
CMJForce (%)	2.55	2.81	2.95	1.86	2.93	5.99	3.61	3.88	6.27
CMJPower (W)	119.72	134.09	141.67	81.41	132.82	278.08	168.93	188.41	302.98
CMJPower (%)	4.98	5.58	5.89	3.38	5.51	11.54	6.87	7.66	12.32
ANOVA (<i>p-value</i>)		0.98			0.45			0.76	

CMJHeight: maximum height of the CMJ; CMJFlight: flight time of the CMJ; CMJVelocity: velocity of the CMJ; CMJForce: force of the CMJ; CMJPower: peak power of the CMJ; UniDSP: Unilateral Dominant Side Protocol; UniNdSP: Unilateral Non-Dominant Side Protocol; AltUniP: Alternate Unilateral Protocol.

Although there are no significant statistics for the CMJ after the different training sessions, when comparing the differences in the results of the means of the CMJ variables of the moments post-training session, 10 and 15 minutes of rest with the means of the variables of the moment pre-training session, it was noticed that there were progressive increases in the results of all variables in all protocols.

4. Discussion

This study aimed to analyze in university handball athletes the influence of maximum strength training in multiple series on the performance in the vertical jump with counter movement before and after different training protocols with knee extension exercises, performed until concentric failure, prescribed in the leg extension. With the data obtained (Table 2), it was verified that the production of strength on the dominant side was greater in all protocols, but higher when performed alternately with the non-dominant side, based on Cohen's principle the effect size was $d = \text{medium}$ for the Total RM variable. It was also observed that the non-dominant side produced more muscle strength in the alternate unilateral protocol when compared to the protocol variables with executions only with the non-dominant side, presenting effect size Cohen's $d = \text{large}$ for the Total RM variable. However, it was evident that there were no contralateral muscle imbalances and/or probable injury risks since the percentage differences in asymmetries did not exceed 10-15% (Fonseca et al. 2007; Croisier et al. 2008; Kyritsis et al. 2016).

Corroborating with the present study, Almeida et al. (2012) verified the isokinetic performance of 23 women, age 22.6 ± 1.8 years old and concluded that both for extension and flexion of the knee the dominant limb presented significantly superior results and the asymmetry between the limbs of up to 10%. Similarly,

Weber et al. (2010) evaluated 27 professional male soccer players aged between 18 and 35 years old using tests on an isokinetic dynamometer and found that all athletes showed asymmetries below 15%, even with significant differences in the lower limbs between dominant and non-dominant sides. On the other hand, the results found by Barcelos et al. (2018) found that in the variables of isokinetic muscle strength between lower limbs, dominant and non-dominant sides of 12 amateur female futsal athletes, age 22.07 ± 3.61 years old, there were no significant differences.

A possible justification between symmetrical differences in the athletes' lower limbs in greater strength production and less perceived exertion would be the dominant limb for preference being more recruited and stimulated in daily motor activities, in training situations and arising from sports demands, generating metabolic changes that provide for greater fatigue resistance and improvements in the ability to overcome higher mechanical overloads (Hodges et al. 2011; Zahálka et al. 2013; Barbieri et al. 2015).

For Picón-Martínez et al. (2019), studies to unleash optimal effects of PAP on the ability to jump are the resistance training sessions for lower limbs, applying 1-3 sets with overloads with intensities of 80-90% of 1RM (i.e., 3-5RM for sets). According to Wilson et al. (2013), when examining the production of elastic energy, one of the main components to maximize PAP concerns the ideal interval after a determined conditioning activity, suggesting to optimally increase the muscle power of 3-7 minutes for athletes and 7-10 minutes for trained individuals. These findings are similar to the results found in this study (Figura 2) because even though there were no statistical differences for the CMJ between the moments pre-, post-training session, 10 and 15 minutes of rest in the different protocols, it was observed a trend to a progressive increase in the variables of the CMJ (statistically not significant), extending up to the 15th minute of rest. At 15 minutes of rest of AltUniP it can be seen the greater difference when compared with pre-training session values: CMJHeight (4.02cm; 11.07%), CMJFlight (30.00ms; 5.55%), CMJVelocity (0.07m/s; 5.41%), CMJForce (118.03N; 6.27%) and CMJPower (302.98W; 12.32%).

Likewise, Della Corte et al. (2020b) analyzed the performance of the CMJ in four male basketball athletes, under-17 category immediately after two distinct training protocols, power training protocol (PTP) and strength training protocol (STP) that consisted of performing one training session with three sets of maximal repetitions until the concentric failure in the leg extension exercise with overloads of 60% and 90% of 1RM, respectively. The experiment revealed that the muscular stresses caused after each protocol did not significantly influence in the results of the CMJ, however the CMJ variables in the PTP decreased and in the STP had an increase of 1% in maximum height, 0.5% in flight time, 0.42% in takeoff velocity and 0.3% in vertical force.

It is noticed that the volume and intensity of the activity previously performed, as well as the control in the rest periods, need to be adjusted with the explosive activity because athletes differ in their strength level, training experience and muscle fiber structure (Lowery et al. 2012; Gołaś et al. 2016). The prolongation of the potentialized effects, the successful execution and optimal performance increases occur when PAP in the stretching/shortening cycle exceeds the fatigue of the contraction/relaxation process (Sale 2004; Struzik 2019). After performing the intense exercise, the muscles will be equally fatigued and enhanced, a relationship called the window of opportunity, where the effectiveness of explosive activity will be determined by its ability to recover glycogen stores without dissipating the potentialized effects (Tillin and Bishop 2009).

5. Conclusions

The investigation revealed that the training sessions with the characteristics prescribed in the present study caused stresses in the muscle tissues of the anterior thighs of male handball athletes from a university team, which positively affected the performance of jumps with counter movement, best perceived in the protocol who simultaneously performed series with the two lower limbs. It was evidenced that the volume and intensity of the maximum strength training sessions, previously performed in the leg extension, with great metabolic demand in short duration activities with high dynamic effort, have an important participation in the jumping performance, which among other factors, the rest period after the conditioning session, favors for the transient improvement of the explosive muscular strength of the athletes.

The sample size can be mentioned as limitations of the present study and not having evaluated female athletes. However, it is highlighted as strengths of the work the characterization of university

handball from Rio de Janeiro, Brazil, in the studied variables, and reinforce the scientific framework regarding the performance in the vertical jump with counter movement before, immediately after the maximum strength training in multiple series, and after 10 and 15 minutes of rest. It is suggested for further investigations of possible injuries the control with biochemical and/or imaging exams, in addition to other exercises and training methods that have different conditioning volumes and intensities, longer post-training recovery time, increased number of participants, of both sexes, of varying ages, with different states of physical conditioning, to observe different yields on individuals' jumps.

Authors' Contributions: DELLA CORTE, J.: conception and design, acquisition of data, analysis and interpretation of data, drafting the article; SOUZA, R.A.: acquisition of data, analysis and interpretation of data, drafting the article; SILVA, J.B. and NEVES, E.B.: conception and design, analysis and interpretation of data, drafting the article; TORRES, J.P.B.: acquisition of data, drafting the article; CASTRO, J.B.P.: analysis and interpretation of data, drafting the article; LIMA e SILVA, L.: conception and design, acquisition of data, analysis and interpretation of data, drafting the article. All authors have read and approved the final version of the manuscript.

Conflicts of Interest: The authors declare no conflicts of interest.

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