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Jumping performance differences among elite professional handball players with or without previous ACL reconstruction

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The protocol of this study was approved by the by the Institutional Review Committee of the Public University of Navarra, SP.

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Abstract

Context: Handball is one of the most challenging sports for the knee joint. Persistent strength and jumping capacity alterations may be observed among athletes who have suffered anterior cruciate ligament (ACL) injury.

Objective: To examine unilateral and bilateral jumping ability differences between previously ACL-reconstructed rehabilitated elite handball athletes and sex, age and uninjured sport activity level-pairs of control players.

Design: Cross-sectional study with one factor: previous ACL injury.

***Setting*:** In the field.

Participants: We recruited 22 male (6 ACL-reconstructed and 16 uninjured control players) and 21 female (6 ACL-reconstructed and 15 uninjured control players) elite handball players who were evaluated 6.2 ± 3.4 years after surgical ACL reconstruction.

Intervention: A battery of jump tests, including both bilateral and unilateral maneuvers, was performed**.** Two-tailed unpaired (intergroup comparison) and paired (intragroup comparison) t-tests were performed for mean comparisons. The P value cut-off for significance was set at < 0.05.

Main outcome measures: Height (m), flight time (s), stance phase contact time (s), mechanical power ($W \cdot kg^{-1}$) and jumping distance (m) values were obtained.

Results: The previously ACL-reconstructed female athletes showed a lower bilateral drop jump contact time (0.429 ± 179.9 vs. 0.349 ± 151 s, $p < 0.05$) and less distance reached (3.820 ± 0.54 vs. 4.428 ± 0.44 m, $p < 0.05$) in the unilateral triple hop for distance (UTHD) on their reconstructed leg compared with the dominant legs of the uninjured control athletes. No significant differences were observed for any other recorded variable.

Among the male athletes, no significant differences between groups were found for the studied jumping variables.

Conclusions: Previously ACL-reconstructed elite female handball athletes demonstrated both lower vertical bilateral drop jump (VBDJ) contact times and lower UTHD scores for the injured leg several years after injury. These deficits could contribute to an increase in ACL reinjury risk.

Key words: *ACL injury, handball, performance, reconstruction*.

Handball is a highly strenuous body-contact team sport with a strong emphasis on running speed, jumping, abrupt changes of direction and throwing [1]. Due to handball´s intrinsic need for abrupt changes of direction and unplanned action management, as well as high game intensity anterior cruciate ligament (ACL) rupture is one of the most frequent devastating injuries among handball players [2, 3]. It is worth noting that female athletes have a greater ACL injury risk than do their male counterparts during the same reproduced jumping and pivoting tasks [4-6]. This greater injury risk has been associated with existing neuromuscular, anatomical and hormonal differences between sexes [7, 8].

An incomplete or deficient rehabilitation program following ACL injury may increase both the reinjury and the contralateral unaffected ACL injury risk [8, 9]. The identification of functional, biomechanical and neuromuscular deficits when discharging these patients from rehabilitation appears to be crucial for ACL reinjury prevention in this population [10].

Noyes et al. [11] first reported an abnormal lower limb symmetry index during the performance of a hop test battery by an ACL-deficient non-elite athletic population. More recently, Myer et al. [12] recommended the utilization of unilateral functional jump tests after ACL reconstruction to examine between-extremity deficits among collegiate recreational athletes. Indeed, many scientific articles have reported biomechanical and neuromuscular alterations during both functional jumps and athletic tasks in the previously ACL-injured population [10, 12]. Therefore, functional performance tests appear to be a clinically relevant option to examine between-extremity functional deficits after ACL injury rehabilitation [13].

Previous studies have highlighted the biomechanical and neuromuscular alterations occurring in the general population and in recreational sport practitioners after ACL injury, both immediately and several years after the original injury [9, 10, 13, 14]. These previously reported alterations have been linked to maximal muscular power output mechanism attenuation and to proprioceptive and neuromuscular control deficits, such as trunk, hip and knee joint kinematics and net internal joint moment alteration [10, 15, 16]. Myklebust et al. [2] previously identified functional, strength and antero-posterior knee joint laxity deficits among previously ACL-injured professional and recreational handball players. However, for elite professional handball athletes, the persistence of these potential alterations several years after the original ACL injury, despite a return to the preinjury activity level, remains controversial.

Accordingly, the objective of the present study was to examine the differences between previously ACL-reconstructed and rehabilitated elite professional handball athletes and sport level, sex and age pairs of uninjured control participants by measuring their jumping performance in a training practice during their regular season. The study hypothesis posited that differences in jumping performance should be present among the previously ACL-reconstructed elite professional handball athletes compared with the control participants, despite several years having passed since the original injury and despite current competition at their preinjury level of sport performance. Due to the higher injury incidence reported among female athletes due to their sex-dependent neuromuscular, biomechanical and physiological characteristics [7], it was hypothesized that the differences would be greater among female athletes than among their male counterparts.

Methods

Design:

A cross-sectional study with one factor (previous ACL injury) was performed to examine jumping performance differences between previously ACL-reconstructed rehabilitated elite professional handball players and sport level, age and sex-pairs of uninjured controls by sex by measuring jumping performance in a training practice during their regular season.

Participants:

The study population consisted of 43 participants: 22 male (6 ACL-reconstructed and 16 uninjured controls) and 21 female (6 ACL-reconstructed (bilaterally in 2) and 15 uninjured controls) elite handball players. The average time (± standard deviation (SD)) since surgical reconstruction was 6.0 ± 3.5 and 6.3 ± 3.4 years in the female and male groups, respectively. All athletes were competing in top-division national leagues. Recruitment was performed through personal interviews with the team managers of each clubThe authors used a convenience sample based on available elite level handball players in the region where the research was carried out. Prior injury records were collected by asking players via questionnaire before starting the testing session. These data were corroborated by consulting the medical staff's injury report at each club. All athletes with previous serious lower limb injury (more than 6-week duration and/or surgical treatment required) in the last 3 years, apart from ACL reconstruction procedures, were excluded from participation in the study.

The age and anthropometric characteristics of both the female and the male athletes are shown in Tables 1 and 2, respectively. The dominant leg was defined as the leg that the athletes would use if they were required to jump and then throw a ball. The distribution of the predefined jumping legs in the studied population consisted of 14 left-limb- and 7 right-limb-dominant female participants and 17 left-limb- and 5

right-limb-dominant male participants. Among the ACL-injured participants, 5 of 6 athletes in the ACL-injured female group had an ACL injury affecting their dominant limb, whereas only 2 of 6 athletes in the ACL-injured male group had a previous ACL injury compromising their dominant leg. The participants and coaches were informed in detail about the experimental procedures and the possible risks and benefits of the project. The project was approved by the Ethical Committee of the Public University of Navarra and performed according to the Declaration of Helsinki.

Procedures:

The participants performed a previously validated and reliable jump test battery for detecting limb asymmetries following ACL injury in athletes. The jump test battery included a vertical bilateral drop jump (VBDJ), a vertical unilateral drop jump (VUDJ), a vertical unilateral countermovement jump (VUCMJ), and two horizontal jumps: the unilateral triple hop for distance (UTHD) and the unilateral cross-over hop for distance (UCHD). For the unilateral jump tests, both the dominant and the non-dominant legs were individually tested in all subjects. Two practice tests were given to each participant to ensure comfort with the task prior to data collection. In all of the tests, the participants were instructed to place their hands on their iliac crest and could not modify that position through the execution of each task. No jumping technique explanation was given in an attempt to avoid execution modification.

The test-retest intraclass correlation coefficients for all anthropometric and jumping variables were greater than 0.95, and the coefficients of variation ranged from 0.94% to 1.5%.

For the VBDJ, the subject was positioned on top of a 50 cm box and instructed to drop off the box, with both feet leaving the box simultaneously and each foot landing on

an infrared curtain system (Sport Jump System Pro, DSD Spain, León, Spain), and then immediately execute a maximal-effort vertical jump.

For the VUDJ, the subject was positioned on top of a 20 cm box and instructed to drop off the box with one foot and, after landing on the infrared curtain system, to execute a maximal vertical unilateral jump. For both jumps, the flight and contact times were measured with the aforementioned equipment.

For the VUCMJ, the subject was asked to perform a unilateral countermovement jump from an extended leg position down to approximately 90° of knee flexion, immediately followed by a concentric action in which the subject jumped to a maximal height. The flight times were measured with the abovementioned equipment.

The UTHD and UCHD were performed as reported by Noyes et al. [20]. For the UTHD, the participants stood on one leg, performed three consecutive horizontal hops as far as possible and landed on the same foot, maintaining the last landing position for at least one second. The total distance hopped was measured.

For the UCHD, the subject stood on one leg and hopped three consecutive times on one foot to cross over a 15 cm-wide and 8 m-long center strip marked on the floor. The subject had to successfully land each hop without falling inside the 15 cm-wide strip marked on the floor and to maintain his/her balance after having landed the last jump for at least one second. The subject had to successfully land each hop without stepping on the strip and to maintain the end of the last jump for at least one second. The total distance hopped was measured.

For the unilateral jump tests, intragroup comparisons were performed between the reconstructed legs and the healthy opposite sides of the injured participants and between the dominant and the non-dominant extremities of the control participants. In the case of athletes with bilateral ACL reconstruction, this analysis was not carried out.

Furthermore, after having confirmed no dominance effect between the extremities among the healthy control participants by performing a two-tailed paired t-test between the dominant and the non-dominant limbs of control subjects, the reconstructed legs were compared with the dominant lower extremities of the control group for the intergroup comparison. This data analysis concerning the intergroup comparison was conducted to avoid any intra-subject compensation bias that may have existed after ACL injury .

All participants performed the test at the beginning of a routine training session that was conducted during the competitive season and at least 48 hours after the last competitive game. For all jumping tests, two trials were performed, interspersed with 10 seconds of rest between repetitions, and the best trial was recorded for further analyses . During the VBDJ, VUDJ and VUCMJ, the flight and contact times (s) were recorded with the infrared curtain system. In the drop maneuvers, the mechanical power $W \cdot kg^{-1}$ output was calculated as previously described in the literature . In the horizontal jump tests, the distance reached (cm) was measured with a standard tape measure.

The lower limb symmetry index (LSI) for the jumping performance of the previously injured athletes was calculated using the following ratio:

$$\frac{\text{Reconstructed limb}}{\text{Contralateral healthy limb}} x100$$

The clinically relevant percentage was set at a more than 15% difference between the achieved intra-subject extremity scores, as previously described in the literature .

Statistical Analyses:

Standard statistical methods were used to calculate the means and SDs. The different outcome measures were verified for normal distribution using the Kolmogorov-

Smirnov test. A two-tailed unpaired t-test was performed for the mean comparison between the subjects' lower limb scores (dominant control vs. previously ACL-reconstructed legs). A two-tailed paired t-test was used to analyze intragroup between-limb differences. The significance level was set at $p \leq 0.05$.

A prospective calculation of sample size was performed using data previously reported by Schiltz et al. and Myklebust et al. for vertical and horizontal jumps, respectively (PS software for power size biostatistics, version 3.0.43, Vanderbilt University, Tenneesse USA). Assuming a power of 80% and a type I error rate of 0.05, the estimated sample size required to accomplish this study was 57 subjects in each group for the VUCMJ, 60 for the VBDJ and 4 for the UTHD. Previous studies' samples were not specific to elite professional handball players. All elite professional handball players in our region were recruited to determine whether jumping performance deficits could also persist among fully trained, highly supervised handball athletes. The post-hoc power analysis revealed that the power value of the present study (based on the present cohort data) was 0.265 for vertical jumps and 0.203 for horizontal maneuvers.

Results

Previously ACL-injured female athletes were on average 8.2 kg lighter and 5.8 cm smaller han uninjured players (Table 1). Regarding function-related variables, previously ACL-injured athletes showed lower VBDJ contact times and less reached distance in the UTHD (Figures 1 and 2). Although no significant differences were reached, there was a trend toward worse performance in the UCHD and VUCMJ among previously ACL-reconstructed elite female athletes (Table 1).

No significant differences (P>0.05) were observed between ACL-reconstructed and non-ACL-injured male participants regarding anthropometric data or jumping performance-related variables (Table 2).

When analyzing the entire data without per sex stratification, no significant differences (P>0.05) were observed between ACL-reconstructed and non-ACL-injured participants regarding anthropometric data or jumping performance-related variables (Table 3).

A comparison between the injured and the uninjured legs revealed no significant differences in the LSI (expressed as the mean LSI score during the entire test battery, resulting from the between-extremity ratio in each test for reconstructed athletes) for either female (100.6 ± 8.1) or male (97.4 ± 2.57%) athletes (Tables 1 and 2).

Discussion

The purpose of the present study was to compare the jumping performance of previously ACL-reconstructed, rehabilitated elite professional handball players who were competing at their preinjury level and sport level, age and sex pairs of non-ACL-injured control athletes by sex. The results revealed that a degree of functional impairment may have existed in the previously ACL injured elite female handball players. Previously ACL-injured, rehabilitated athletes showed lower VBDJ contact times and diminished UTHD performance compared with the non-ACL-injured

group. The rehabilitated male players did not show differences between the reconstructed leg and the healthy contralateral side or between the reconstructed leg and the dominant or non-dominant leg of the uninjured elite male controls. The LSI did not reach a clinically relevant percentage in our entire previously ACL-injured study sample.

In the present study, the previously ACL-injured, rehabilitated and competing elite female handball players showed lower contact times during the VBDJ and a lower reached distance in the UTHD compared with the uninjured sex, age and sport level-pairs of controls. These players were also reported to be significantly smaller and lighter than the non-ACL-injured controls.

Although many articles have reported both functional and biomechanical dysfunctions after ACL injury [8, 18, 25], to the best of our knowledge, this study is the first to report a decrease in jumping performance among previously ACL-reconstructed elite female handball players who have returned to a high athletic competition level.

The reason why jumping-related differences were found in the present study among female but not male athletes could be controversial. Lower contact times could be the result of a knee joint stiffening strategy, and the attenuated horizontal jumping capacity may be explained by both muscular activation pattern modification and by persistent strength deficits, which have been previously described in the literature [23-25, 27]. Several authors have concluded that the reported weakness may be attributable to activation failure at maximal force output [6, 7]. This statement is based on the assumption that following traumatic and degenerative joint damage, inhibition of quadriceps muscle full activation may occur. Indeed, the extent of the reduction in the quadriceps' activation appears to be related to the sustained joint damage [14]. This muscular inhibition mechanism may be explained by inflammation that results in

impaired muscle proprioception because of gamma motoneuron sensitivity reduction (affecting both movement appreciation and control) and alpha motoneuron excitability reduction (causing the activation failure at the quadriceps femoris muscle level). Thus, it appears that both joint mechanoreceptors and other pain signaling mediators may be involved in the quadriceps femoris muscle inhibition phenomenon observed after serious knee joint injury. This maximal force output attenuation after serious knee injury [14] could be accentuated in females compared with males because of different muscle activation strategies and internal developed moments around the knee joint that were previously described in the literature[16, 21]. Thus, females appear to be more susceptible to incomplete functional recovery after ACL reconstruction compared with males [1, 21, 26, 31]. The results of our study could be linked to the movement pattern adaptation shown in the literature after ACL injury, leading the injured female athlete to adopt non-conscious reinjury avoidance via a function-limiting strategy.

This sex-dependent ACL injury mechanism has been proposed to be due to neuromuscular, hormonal and anatomical factors [11, 17]. Hewett et al.[13] prospectively reported several biomechanics indices that were able to predict ACL injury among 205 healthy female recreational athletes. Athletes who subsequently experienced a noncontact ACL injury demonstrated higher vertical ground reaction force (VGRF) (20%) values and shorter (16%) contact times during the VBDJ maneuver in comparison with athletes who did not have an ACL injury. In this context, Zebis et al. [35] performed an Electromyographic examination during specific athletic maneuvers executed by professional female handball players and followed the enrolled subjects during two competition seasons. These authors reported that the subsequently ACL-injured athletes showed lower preactivation levels in the semitendinosus muscle and increased activation levels in their vastus lateralis compared with those athletes

who were not injured. Furthermore, different research studies have suggested that disturbed knee motion patterns in women tend to increase the load on the ACL and therefore expose more female athletes than male athletes to ACL injury

Previous studies have reported functional deficits in a wide but generally mixed group of athletes following ACL reconstruction [11, 15]. Due to evident methodological difficulties, the literature focusing on ACL injury-related functional alterations in elite professional handball athletes is limited. In agreement with our results, Mycklebust et al. [2] reported functional alterations among elite and recreational female and male handball players 6 to 11 years after ACL injury. The authors reported compromised knee function in approximately half of the previously ACL-injured players who were treated surgically or non-operatively based on knee functional jumping test results, radiologic findings, strength measurements and function-related knee questionnaires. However, in contrast to the present study, the previous study examined a heterogeneous group of elite and recreational athletes and did not analyze outcome variables separately for different sport activity levels or sexes. In addition, the authors did not indicate the proportion of players who returned to their preinjury level. The fact that all players in our study had resumed their previous elite sport level makes the sample in the present study potentially relevant for team physicians who manage the functional status of previously ACL-reconstructed professional athletes in the field.

Regarding the anthropometric differences between previously reconstructed female athletes and non-ACL-injured female controls, in our opinion, this difference may due to a possible playing position effect. Outside players may be more exposed to ACL injury risk due to more demanding plant and cut-type movement requirements, which have been previously described as a cause of ACL injury . We suggest that this issue

should be addressed in the future by properly designed descriptive studies with larger sample sizes.

One of the key points in the present study is the between-sexes data analysis. The observation that only the female group of athletes showed jumping performance-related differences in our study(neither among male or both male and female group of athletes altogether), could be explained by the accepted presumptions that female athletes are more exposed to ACL injuries than are males [32] and that the strongest predictors of ACL injury risk, such as knee valgus excursion and hip external rotation weakness, are more frequent among females [8, 17] and are much more reproduced among females than among males [9, 19]. Moreover, it is believed that female athletes should not restore full function in the same way and at the same time as do male athletes [33] and that female athletes cannot restore their previous sport performance as well as males can after ACL reconstruction [34]. Considering the high ACL reinjury rate (22%) previously reported in the literature [2] and in our study (14%), the results of the present study could help clinicians to consider the implementation of functional performance tests to check the function of previously ACL-injured athletes and decrease (if deficits are identified and corrected) the ACL reinjury risk [6, 12].

No differences were observed in the jumping performance-related variables among the male handball players. The encountered absence of differences between the previously ACL-injured athletes and the uninjured sex, age and sport level-pairs of control participants could be related to a less predominant ACL injury-facilitating motion pattern among male athletes than among their female counterparts [8, 19]. Accordingly, a return to the previous activity level after an ACL injury has been demonstrated to be more frequent among elite male athletes than among their female counterparts [34]. It should be also highlighted that both the small sample size and the fact that only

athletes able to resume previous sport level were included. This fact could have affected between groups differences identification. In the author´s opinion this point is crucial in the present investigation since the aim of the present study was precisely to target this issue, if athletes competing at the top level after having suffered and ACL reconstruction, would still exhibit some jumping related alterations that could affect either their performance or their reinjury chances.

The LSI did not reach a clinically relevant percentage (< 85%) [32] in the present investigation. Similar to our study, other authors have reported no differences in the LSI among previously ACL-reconstructed participants [35]. However, many other studies have encountered relevant differences between ACL-reconstructed and contralateral healthy legs [11, 20]. This controversy regarding reported LSI values in the previously ACL-injured population could be due to several factors. First, previous laboratory studies have shown that greater VGRF absorption may be supported by the contralateral non-ACL-injured leg, potentially affecting its jumping capacity and thus complicating the identification of between-extremities differences [10, 16]. Second, our study sample comprised elite professional handball players. Thus, a reinforcement effect due to the high-intensity training is possible, attenuating possible between-extremities differences that other groups previously found among recreational, non-professional athletes . Finally, sex non-discrimination and heterogeneity in the time passed since the original ACL injury could serve as confounding factors when analyzing the LSI as a clinical parameter.

A unique potential clinical implication of the present study was that through vertical and horizontal jumping performance examinations, clinicians will be able to detect persistent function-related deficits among previously ACL-injured elite professional female handball players, even if several years have passed since the

original injury. Thus, the identification of specific function-related abnormalities could lead to personalized ACL prevention training programs. The clinical relevance of this measurement technique should be considered due to its low cost and high applicability. More research is needed to assess whether a correlation exists between functional performance tests and biomechanical, strength and proprioceptive disorders that seem to coexist during the function restoration process after ACL injury reconstruction.

One potential limitation of the current study is that despite the time passed since the original injury was registered, the postoperative rehabilitation protocol among those athletes with a previous ACL injury was not controlled. The jump battery protocol was fixed. The elected criteria used for jump task execution order was from easy to complex execution requirements to avoid possible injury risk associated with the intensity of the jumping tasks.

A more comprehensive study evaluating the same hypothesis and controlling the rehabilitation following ACL injury would increase the power of these findings. The post-hoc power analysis revealed that the power value of the present study was 0.265 for vertical jumps and 0.203 for horizontal maneuvers. Although we concede that the power of the study could be an important limitation, according to the objectives of the present study, our intention was to recruit all of the elite professional handball players available in our region. We focused on athletes with an elite professional profile because we wanted to know whether jumping performance deficits could also persist among fully trained, highly supervised handball athletes. Interestingly, previous work examining similar variables related to jumping performance was performed with previously ACL-injured non-professional athletes and with analogous sample sizes.

In summary, previously ACL-reconstructed elite female handball athletes demonstrated lower VBDJ contact times and lower UTHD scores in their injured leg

several years after the injury occurred, thereby potentially increasing their ACL reinjury risk. The restoration of these deficits following an ACL injury prior to returning to a high athletic competition level would help to decrease the reinjury rates in this population. The identification of ACL injury-facilitating motion patterns in this population seems to be crucial for the implementation of effective and deficit-based on-the-field ACL prevention training programs. More research is needed to develop clinical rehabilitation algorithms that objectively guide the patient in the improvement of all of the identified deficits prior to returning to sport participation.

Conclusions*:*

Our study showed that previously ACL-reconstructed elite female handball players who had returned to a high athletic level of competition still presented limited jumping performance compared with age-, sex- and sport level-pairs of non-ACL-injured controls, even when several years had passed since the original injury and return to competition. From a clinical point of view, a reproducible, validated and low-cost hop test battery can identify function-related deficits among previously ACL-reconstructed elite female handball players.

In this context, vertical and horizontal jumping performance examinations can detect persistent function-related deficits among previously ACL-injured elite professional female handball players in particular, even if several years have passed since the original injury. Thus, monitoring the functional status of ACL-reconstructed athletes individually using clinically available tools may be of interest for athletic trainers and team physicians to minimize the ACL reinjury risk on the field.

TABLE 1. Descriptive data of jump test battery variables among female athletes.

TABLE 2. Descriptive data of jump test battery variables among male athletes

TABLE 3. Descriptive data of jump test battery variables among female and male athletes

FIGURE 1: VBDJ contact times among female handball players

FIGURE 2: UTHD reached distance among female handball players

TABLE 1. Descriptive data of jump test battery variables among female athletes.

		Controls (n=15)		ACL reconstructed (n=6)	
		Dominant	Non dominant	Injured	Non injured
Age (years)		25 ± 5.1		26 ± 4.0	
Weight (Kg)		70.2 ± 5.1		61.8 ± 3.9*	
Height (cm)		174.8 ± 6.1		169.0 ± 4.4*	
Vertical Bilateral Drop Jump [a]	Flight time (ms)	484.4 ± 27.7		451.7 ± 40.6	
	Contact (time)	429.4 ± 179.9		349.4 ± 151.1*	
	Mechanical Power Output ($W \cdot Kg^{-1}$)	27.5 ± 3.1		25.9 ± 5.8	
Vertical Unilateral Drop Jump	Flight time (ms)	346.5 ± 26.1	337.3 ± 26.6	330.3 ± 45.2	334.7 ± 43.8
	Contact (time)	403.9 ± 184.1	412.8 ± 193.7	357.9 ± 174.3	283.01 ± 206.28
	Mechanical Power Output ($W \cdot Kg^{-1}$)	9.1 ± 5.2	8.7 ± 5.2	9.9 ± 6.6	12.2 ± 6.1
Verttical Unilateral Counter Movement Jump	Flight time (ms)	345.3 ± 21.9	357.5 ± 53.4	320.6 ± 41.7	350.3 ± 25.1
Unilateral Tripe Hop for Distance	Distance (cm)	442.9 ± 44.7	430.3 ± 47.9	382.0 ± 54.6*	398.3 ± 87.8
Unilateral Cross Over Hop for Distance	Distance (cm)	326.1 ± 44.8	330.9 ± 58.5	289.6 ± 58.2	310.5 ± 70.1
Lower Symmetry Index (LSI)	%			100.63 ± 8.06	

Abbreviations: Kgs. kilograms; cm. centimeters; ms. miliseconds; $W \cdot kg^{-1}$. $Watts \cdot kilograms^{-1}$.

*Denotes statistically significant differences between previously ACL injured and controls´dominant limbs.

LSI were only calculated among previously reconstructed athletes

ª Bilateral drop jumps parameters were provided with one jumping platform therefore, both legs landing on the same place, and reporting an unique data

TABLE 2. Descriptive data of jump test battery variables among male athletes.

		Controls (n=16)		ACL reconstructed (n=6)	
		Dominant	Non dominant	Injured	Non injured
Age (years)		24 ± 5.1		27 ± 3.1	
Weight (Kg)		89.8 ± 9.9		92.1 ± 8.5	
Height (cm)		188.2 ± 7.0		188.3 ± 5.7	
Vertical Bilateral Drop Jump[a]	Flight time (ms)	541.5 ± 40.1		543.3 ± 52.8	
	Contact (time)	308.5 ± 7.3		328.7 ± 81.0	
	Mechanical Power Output ($W \cdot Kg^{-1}$)	25.4 ± 6.3		30.6 ± 5.4	
Vertical Unilateral Drop Jump	Flight time (ms)	422.4 ± 44.6	405.8 ± 41.5	403.1 ± 34.8	416.0 ± 38.1
	Contact (time)	322.7 ± 19	319.7 ± 114.0	358.7 ± 157.9	354.5 ± 136.4
	Mechanical Power Output ($W \cdot Kg^{-1}$)	15.1 ± 6.5	14.0 ± 5.6	12.3 ± 4.0	13.2 ± 4.9
Vertical Unilateral Counter Movement Jump	Flight time (ms)	406.2 ± 44.7	392.3 ± 38.9	389.9 ± 40.4	395.5 ± 59.7
Unilateral Tripe Hop for Distance	Distance (cm)	489.4 ± 126.3	452.0 ± 73.1	540.3 ± 101.0	563 ± 53.1
Unilateral Cross Over Hop for Distance	Distance (cm)	445.5 ± 72.0	442.7 ± 86.6	444 ± 81.3	473.7 ± 67.0
Lower Symmetry Index (LSI)	%			97.4 ± 2.6	

Abbreviations: Kgs. kilograms; cm. centimeters; ms. miliseconds; $W \cdot kg^{-1}$. Watts·$kilograms^{-1}$.

LSI were only calculated among previously reconstructed athletes

ª Bilateral drop jumps parameters were provided with one jumping platform therefore, both legs landing on the same place, and reporting an unique data