ANALYSIS OF LOWER LIMB BILATERAL FORCE ASYMMETRIES BY DIFFERENT VERTICAL JUMP TECHNIQUES

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This study has compared the diagnostic information of lower limb bilateral force asymmetry by the impulse variable at different vertical jump techniques. Twenty-nine soccer players carried out six attempts at each of the vertical jumps, countermovement jump and squat jump, on two synchronized force platforms. After the calculation of the symmetry index, the athletes were classified as symmetric and asymmetric respecting a cut-off value of 15%, McNemar's test compared the diagnostic information among the techniques. Significant differences were found among the diagnostic information of the different techniques ($p<0.05$). It is thus concluded that different vertical jump techniques provide different information in regards to the level of bilateral force asymmetry in soccer players.

KEY WORDS: lower limb, asymmetry, countermovement jump, squat jump, soccer player.

INTRODUCTION: The isokinetic test is commonly applied on the identification of bilateral force asymmetries (BFA) in soccer players (Moss & Wright, 1993). However, such test presents few similarities to sport movement standards in which the angular speeds vary constantly (Mayer et al., 2003) and the movements are normally carried out in a closed kinetic chain (Impelizzeri et al., 2007). This way, for the evaluation of athletes, the tests in closed kinetic chain that uses dynamic actions (Wilson & Murphy, 1996), such as the vertical jumps (Impellizzeri et al., 2007), could present more adequate information about the BFA. Therefore, the vertical jumps carried out on the force platform for obtaining the ground reaction force (GRF) have been used for the identification of the BFA in lower limbs (Impelizzeri et al., 2007; Menzel et al., 2013; Benjanuvatra et al., 2013).

Among the vertical jumps, the countermovement jump (CMJ) and the squat jump (SJ) stand out given that in both techniques the GRF represent the sum of force momentums of the lower limb joints and involve joint accelerations (Gantiraga et al., 2006). The CMJ is a widely used technique due to its similarity to the motor demands in soccer (Stalbom et al., 2007) once it requires quick muscle contractions which demand from the stretch-shortening cycle (SSC). The SJ, on the other hand, is a technique used as a tool for prescribing and controlling training loads, providing specific information on the efficiency of the concentric muscle actions of lower limbs (Hasson et al., 2004). Besides, this technique presents a high correlation with the technique of volleyball attack, the Spike Jump ($r = 0.76$; $p = 0.001$), demonstrating that even with the evaluation of only the concentric actions of the lower limbs this ability can be considered as being specific for the evaluation of athletes (Hasson et al., 2004).

To the best of our knowledge, only one study was found which has identified the bilateral force asymmetry through the use of the SJ and this identification was done with a very specific population of athletes, soccer goalkeepers (Zahalka et al., 2013). Besides that, this study has compared only the values of the BFA and has not verified if the diagnostic information provided by the symmetry index (SI) were similar. In this sense, it is necessary a study that seeks a better understanding of the diagnosis of force asymmetries in different motor tasks (CMJ and SJ) in order to assist professionals in training planning and adapting and in the early identification of athletes who are more likely to develop muscle injuries (Croisier et al., 2008). This way, estimating bilateral force asymmetries of lower limbs through the SJ could be as efficient and applicable to the daily sport training as through the analysis of the CMJ. Therefore, the objective of the present study was to verify the

concordance of the diagnostic information of bilateral force asymmetries in soccer players measured by different vertical jumps, countermovement jump and squat jump.

METHODS: Prior to the study, ethical approval was obtained from the university research ethics committee and written formal consent was given by all participants (CAAE: 31058414.2.0000.5149). The subjects of this study were 29 male soccer players (age = 27.4±4.5 years; body mass = 78.7±8.7 kg; & stature = 1.75±6.8 m) from a professional soccer team competing in the second division of the Brazilian National Soccer Championship.
Two synchronized force platforms were set side by side and used in order to quantify the kinetic variation in the impulsion phase of the vertical countermovement and squat jumps (AMTI OR5-6) adjusted to a data collection frequency of 1000 Hz and lowpass butterworth filter at 50 Hz with a fourth-order (Menzel et al., 2013). This frequency was chosen to allow the extraction of the variable in a more accurate way. The software Dasylab® 10.0 was used for the acquisition of the force vs. time curves. In this procedure the volunteers were asked to perform the jump as high as possible, keeping their hands on their waist during the movement. The subjects performed a single series of six jumps of each technique (CMJ & SJ) with a recovery interval of 30 seconds after each trial. The jump with the highest vertical impulse was selected for further analysis. After collecting the signals (GRF), the force vs. time curves of each lower limb were summed which enabled the determination of the beginning of the curve. The sum of the two GRF curves was denominated resulting curve. The resulting curve provided the identification of the beginning of the motion, which was associated to CMJ when the force values in the force vs time resulting curve were about 5% lower than the individual's body weight and to SJ when the force values were about 5% higher than the individual's body weight. The end of the movement was determined when the force values reached the zero-point, which marked the beginning of the flight phase. After identifying the beginning and end of the propulsion phase of the jump, the impulse was extracted (Araújo, 2015). The impulse is represented by the integration of the force vs time curve in the propulsion phase. A mathematical routine was developed in the Matlab® 2011b software in order to obtain the variable. The bilateral force asymmetries were quantified by the symmetry index, according to Clark (2001): SI *(%) = ((value of the right limb – value of the left limb)/ greatest value of both limbs)*100*. A positive SI indicates higher values of impulse of the right leg, and a negative SI indicates higher values of the left leg, regardless of the athlete's laterality.
Therefore, bilateral force asymmetries of over 15%, which were considered to be relevant (Croisier et al, 2008; Menzel et al., 2013), were identified for the vertical impulse. Thus, all subjects were classified as "symmetric" or "asymmetric" based on the bilateral force asymmetry.
McNemar´s χ^2 test was used to verify the concordance of asymmetry identified by the two different vertical jumps. For all statistical procedures the software SPSS 15.0 was used and a 5% level of significance was applied to map significant data.

RESULTS: Table 1 shows the descriptive data for impulse and for the SI.

Table 1
Descriptive data (mean ± SD) of CMJ and SJ assessment and SI*

	Right lower limb vertical impulse	Left lower limb vertical impulse	Symmetry index	Absolute symmetry index
CMJ	129.63±28.48	104.37±31.03	18.11±24.50	26.62±14.35
SJ	115.81±17.49	100.34±14.74	12.14±14.74	14.96±11.75

*CMJ = countermovement jump; SJ = squat jump; SI = symmetry index.

Table 2 shows the 2x2 tabulation of the diagnostic information of the individuals in symmetrical and asymmetrical in the two different vertical jump techniques.

Significant differences were found in the diagnostic information between the different jump techniques (χ^2 = 5.815; *p* = 0.001; *Cramer´s V*: 0.448).

Table 2
Crosstabulation of asymmetry assessment by impulse of countermovement jump and squat jump

		ΔI_{SCM}		p
		Symmetric	Asymmetric	
ΔI_{SA}	Symmetric	8	11	0.001#
	Asymmetric	0	10	

*ΔI_{SCM} = classification of bilateral force asymmetry of countermovement jump; ΔI_{SA} = classification of bilateral force asymmetry of squat jump; # = significant difference.

DISCUSSION: The objective of the present study was to verify the concordance of the diagnostic information of bilateral force asymmetries of lower limbs at impulse variable in different vertical jump techniques carried out on two force platforms.
The impulse variable was chosen to evaluate BFA due to it being considered the most relevant biomechanical variable for explaining performance in vertical jumps (Impellizzeri et al., 2007; Benjanuvatra et al., 2013; Menzel et al., 2013). The choice also corroborates Menzel et al. (2013) which state that the physical demands of soccer athletes are characterized by rapid changes of maximum direction and acceleration in short distances and the preference and ease of an athlete in performing such movements only to one side may be linked to a different impulse production among limbs. Besides that, these same authors (Menzel et al., 2013) verified that this variable was more sensitive in the identification of individuals as asymmetrical than the other variables evaluated throughout the vertical jumps.
In regards to the results presented, it was identified that there was no concordance in the diagnostic information of the BFA measured by the CMJ and SJ tests of the evaluated group (χ^2 = 5.815; *p* = 0.001). Reinforcing the findings of the present study, Impellizzeri et al. (2007) stated that the use of tests with different motor and coordinative demands will provide unequal values. In that direction, Zahalka et al. (2013) verified greater values of bilateral force asymmetries in lower limbs of goalkeepers in the vertical countermovement jump technique with upper limbs' movement (CMJ_{arms}) than in the CMJ and SJ techniques (CMJ_{arms} = 8.61%; CMJ = 7.06%; SJ = 3.95%). This result was justified by the authors as due to the specificity of the moments made by goalkeepers during training practices and official matches which involve jumps with the movement of the upper limbs.
The different characteristics of the CMJ in relation to the SJ can also support the explanation of the findings of this study. Studies show that the behavior of kinetic variables can be different according to the jump technique being used (Bobbert et al., 1996). While the CMJ uses the SSC, the SJ is done only through the contractile system. Ugrinowitsch & Barbanti (1998) still point out that in the SJ the time for a force production equivalent to the CMJ would have to be bigger, since it's not ballistic, but that is not possible and therefore the level of development of the force is lower. This way, the diagnostic information of the BFA can also be different.
Other studies are necessary in order to determine the efficacy of the use of the bilateral force asymmetries identified at the vertical jumps in recognizing athletes more prone to injury.

CONCLUSION: The results of the present study indicate that vertical jump tests are effective in identifying bilateral asymmetries in soccer players, however, they are independent methods for their evaluation. Therefore, it is necessary to verify which motor demands required of the athletes being evaluated are more similar to the techniques of the vertical jumps.

Thus, with the specific test being applied for the identification of bilateral strnegth asymmetries, effective physical training for the correction of these asymmetries could be applied by the physical trainers of sports teams.

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