ANALYSIS OF THE RELIABILITY OF TWO FORCE PLATFORMS FOR THE SIMULTANEOUS COLLECTION OF KINETICS VARIABLES

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The bilateral force asymmetry between lower-body limbs is seen as one of the major causes of injury and decreased performance in sport. The diagnosis can be done through many measuring methods, instruments and protocols. One of the most validated methods in literature is the vertical jump with countermovement performed on a force platform. Many studies show measurement protocols of jumps performed on a force platform where the jumps are carried out in a unipodial or bipodial manner and the data collection takes place in an alternated or sequential way. This study intends to assess the reliability of two force platforms measuring (maximum force and impulse) simultaneously. The results have indicated that the method used is reliable for the collection of the mentioned variables.

KEY WORDS: bilateral asymmetry, kinetic variables, force platform, countermovement jump.

INTRODUCTION: The bilateral asymmetry (BA) among limbs is considered by many authors as one of the major causes of decreased performance and injury in sport (Menzel, Chagas & Cruz, 2006; Silva, 2008; Teixeira & Paroli; 2000; Impellizeri et al*.,* 2007; Medeiros, 2013), especially in high performance sport (Ceroni et al., 2012).The diagnosis of the BA allows for more adequate training or rehabilitation programs to be elaborated (McElveen et al*.,* 2010), reducing the occurrence of injury in athletes (Croisier et al., 2008).
This diagnosis may be done through different measurement methods, instruments and protocols. Depending on the specificity of the sport, different tasks can be used for this evaluation, such as the horizontal and vertical jumps and their variations (Impellizzeri et al., 2007), isometric tests for the extension of the knee articulation (Newton et al., 2006), 1 RM tests (Moss & Wright, 1994), isokinetic tests (Croisier et al., 2008) and squat exercise (Flanagan & Salem, 2007; Newton et al., 2006). While performing the vertical jump with countermovement (CMJ) in a monopodal or bipodal way on a force platform (FP) it is possible to assess kinetic variables such as maximum force (F_{max}) and impulse (Menzel et al*.,* 2013). However, it is only possible to analyze and compare the performance in different trials, as it has been done in the study of Impellizzeri et al. (2007). According to Cordova and Armstrong (1996) and McElveen et al*.* (2010) these variables are consistent for the identification of the BAs. In tests carried out with two Force Platforms (FP), it is possible to analyze the jump both in a sequential and simultaneous way. The main advantages of this method are the data analysis in a single trial and the reduction of the number of valid jumps (Medeiros, 2013). All in all, to the best of our knowledge, the reliability of the kinetic variables Maximum Force and Impulse measured on two force platforms has yet to be determined.
Therefore, the objective of this study is to investigate the reliability of the kinetic variables (F_{max} and Impulse) obtained through the simultaneous collection of ground reaction force in two synchronized Force Platforms.

METHODS: The study included 16 national-level athletes of Tae Kwon Do (3 women and 13 men), with an average age of 20.00 (± 5.18) years and in average 10.68 (± 4.85) years of sports practice. Table 1 shows the anthropometric characteristics of this sample. The anthropometric measurements were held at the same day of the data collection. This study was approved by the Local Ethical Committee.

Table 1
Anthropometric Characteristics of the Sample

Variable	Female (n =3)		Male (n=13)	
	$\overline{x}$	SD	$\overline{x}$	SD
Mass (Kg)	59.36	13.75	69.86	16.40
Height (cm)	166.66	7.50	175.15	7.72

$\overline{x}$ – mean; SD – standard deviation

Two synchronized force platforms mounted side by side were used in order to quantify the kinetic variation of ground reaction force (GRF) in the impulsion phase of the vertical countermovement jump (AMTI OR5-6) adjusted to a data collection frequency of 1000 Hz (Menzel et al., 2013). This frequency was chosen to allow the extraction of all the variables in a more accurate way. The software *Dasylab*® 10.0 was used for the acquisition of the force x 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 with a recovery interval of 30 seconds after each trial.
After collecting the signals (GRF), the force x 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 determined when the force values in the force x time curve were lower than the individual's weight (negative acceleration of the movement – descending), and the end of the movement, which was determined when the force values reached zero-point at which the beginning of the flight phase or the loss of contact with the force platform is indicated.
After identifying the beginning and end of the propulsion phase of the jump, the F_{max} and impulse variables were extracted. The impulse is represented by the integration of the force x time curve and the maximum force corresponding to the highest value found in the force x time curve in the propulsion phase. A mathematical routine was developed in the *Matlab*® 2011b software in order to obtain the variables.
The intraclass correlation coefficient (ICC) was calculated between the jumps, for each variable (maximum force – ICC_{Fmax} and impulse - $ICC_{impulse}$) and for each limb (right and left side) in the *Statistical Package of the Social Sciences* (SPSS) version 17.00 (SPSS Inc.). The significance was considered at the α level of $p < 0.05$.

RESULTS: The results of the impulse, maximum force, ICC, and Standard Error Mean (SEM) values for each limb are shown in tables 2 and 3.

Table 2
Impulse (I) values for lower-body limbs

I (N.s)	$\overline{x}$	SD	SEM	ICC	p
Right leg	167.00	47.62	20.98	0.94	0.001
Left leg	164.01	45.86	19.24	0.93	0.001

$\overline{x}$ – Mean; SD – standard deviation; p – statistical value

Table 3
Maximum force (F_{max}) values for lower-body limbs

F_{max} (N)	$\overline{x}$	SD	SEM	ICC	p
Right leg	806.26	171.61	56.78	0.90	0.001
Left leg	803.85	160.88	65.61	0.86	0.001

$\overline{x}$ – Mean; SD – standard deviation; p – statistical value

DISCUSSION: The purpose of this study was to examine the reliability of the kinetic variables (F_{max} and Impulse) obtained through the simultaneous collection in two

synchronized Force Platforms. The use of two synchronized force platforms allows the measurement of both dynamics variables in a simultaneous way, which enables the extraction of the variables in the same jump trial and the use of two synchronized force platforms also allows volunteers to perform a smaller number of trails than in one force platform (Medeiros, 2013).
In literature, ICC values between 0.75 and 1 are interpreted as reliable (Cicchetti, 1994; Menzel et al., 2012), therefore, the results presented indicate that the two synchronized force platforms mounted side by side are reliable for the measurement of the kinetic variables (F_{max} and Impulse) when collected in a simultaneous way.
The values found in this study for the F_{max} variable corroborate Medeiros (2013) in which the collection was carried out in two force platforms and presented values of ICC_{Fmax} of 0.85. This study also achieved similar results to the ones found by Impellizieri et al. (2007), Cordova and Armstrong (1996) and Cronin et al. (2004), ICC_{Fmax} of: 0.91; 0.94; 0.86-0.93, respectively. However, these studies used only one force platform to measure such variable.
For the impulse variable the results presented corroborates Medeiros (2013) which presented the value of $ICC_{impulse}$ = 0.86, and also corroborates McElveen et al. (2010) in which they found $ICC_{impulse}$ = 0.80 for the dominant lower-body limb, and $ICC_{impulse\ =}$ 0.65 for the non-dominant lower-body limb. However, the result is not similar to the one presented by Cordova and Armstrog (1994) in which they found the value of 0.22 for $ICC_{impulse}$.
It is possible to observe in the current study that two force platforms with simultaneous collection presents kinetic variables with ICC values higher than 0.80, interpreted, according to Cicchetti (1994), as reliable.
However, even with the positive results in this study, there is a need for further investigation of the dynamics variables, impulse and maximum force, with a larger number of athletes practicing different sports. And futures studies are necessary to evaluate the reliability of the bilateral asymmetry evaluated in the two synchronized force platforms.
Despite of being reliable and allowing a smaller number of trials, the two force platforms are very expensive equipment to evaluate the dynamics variables and its acquisition can be a financial problem for sports teams.

CONCLUSION: It is concluded that the instrument assessed demonstrated reliability for the collection of the kinetic variables F_{max} and impulse with two force platforms in a simultaneous way at a 1000Hz frequency, being suited for the collection of the mentioned variables in athletes in order to diagnose bilateral asymmetry. However, new studies are suggested in order to assess other variables to assure if the procedure is adequate in the identification of BA.

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