ANALYSIS OF LOWER LIMBS' STRENGTH AND ASYMMETRIES BY ISOKINETIC AND VERTICAL JUMP TESTS

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The aim of this study was to verify the correlation between biomechanical characteristics of muscle force measured by isokinetic and vertical jump tests for each lower limb. Peak torque and total work of 46 professional male soccer players were assessed with an isokinetic dynamometer at 60°/s, 120°/s and 180°/s and maximal strength, maximal power and impulse were determined during countermovement jump (CMJ) on a double force platform. A factor analysis of all analyzed variables resulted in two independent factors (F1, F2), where factor F1 is characterized by peak torque and total work at 180°/s and factor F2 by maximal power and impulse during CMJ. Only low correlations between the variables determined by isokinetic test and CMJ were observed.

KEY WORDS: Isokinetic test, force platform, countermovement jump

INTRODUCTION:

Unilateral demand, as kicking in soccer, might lead to differences in motor ability, especially strength and coordination and result in a functional asymmetry of the lower limbs that causes mechanical overload and compensatory mechanisms affecting movement technique and posture (Maupas *et al*., 2002). Isokinetic dynamometry is a common method for the analysis of dynamic characteristics of the lower limbs and the identification of bilateral asymmetry. This method involves open chain movements with a constant angular velocity during the whole range of motion and it is used as test of dynamic variables related to lower limbs' strength, such as work, power and muscular torque (Pincivero, 1994). Recent studies, however, indicate low correlations between global dynamic performance and isokinetic variables (Mognoni *et al.*, 1994, Murphy & Wilson, 1997). Therefore, diagnostic methods of closed kinetic chain movements, such as vertical jumps, have become more important in athletes' evaluation, since they are similar to performance in sports (Augustsson & Thomé, 2000). Whereas isokinetic variables are subsequently obtained for each limb, vertical jumps, e.g. countermovement jumps (CMJ) are performed with both limbs simultaneously. Therefore, the aim of this study was to verify the correlation between variables of the ground reaction force during CMJ on a double force platform and isokinetic variables of each lower limb at different angular velocities.

METHODS:

46 male professional soccer players from two Brazilian elite soccer teams participated in this study. Subjects who's anthropometric characteristics are shown in Table 1, were only included in the study if they had no recent injury of the lower limbs or spine.

Table 1. Anthropometric characteristics of the subjects

Variable	Mean ± sd	N
Age (years)	24,76 ± 3,22	46
Height (cm)	179,48 ± 5,77	46
Mass (Kg)	77,78 ± 7,46	46

After 5 min warm-up exercises, the subjects performed an isokinetic test (Biodex 3 System Pro - Biodex Medical Systems, INC, NY, USA) for each lower limb in order to determine peak torque (PT) and total work (W) at angular velocities of 60°/s, 120°/s and 180°/s for concentric knee extension.

After a 10 min rest, three countermovement jumps (CMJ) were performed on a double force platform (PLA3-1D-7KN/JBAZb, Staniak, Poland). The ground reaction forces were registered seperately for each leg at a frequency of 1 KHz. The subjects were instructed to fix their hands at the hips, in order to avoid upper limbs' movements and to jump with maximal effort (Figure 1). A recovery interval of 2 minutes between the jumps was imposed to avoid fatigue. During CMJ, maximal power output (P_{max}), maximal force (F_{max}) and impulse (IMP) were determined separately for each lower limb and the jump with the best performance (highest impulse) was considered for data analysis.

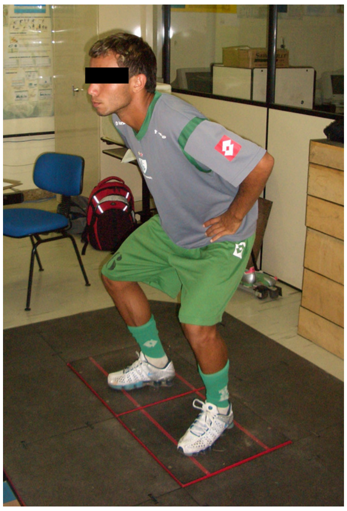

Figure 1: Countermovement jump on a double force platform

In order to discover the factoral structure of these variables, a principal component factor analysis with Varimax rotation was applied. That way, independent orthogonal factors can be extracted. Factor analysis was performed seperately for the variables of each test (isokinetic test and CMJ on a double force platform) in order to identify those variables which represent the test procedure. Then the representative variables of each test procedure were analyzed together by a second factor analysis. Each factor analysis was performed for the right and the left legs as well as for lateral differences. Lateral differences were calculated as relative differences according to Barber *et al.* (1990) and Clark *et al.* (2001) as:

(value of right limb–value of left limb)/greatest value of both limbs)

That way, positive values indicate a a dominant right limb and negative values a dominant left limb.

RESULTS:

The factor analysis of the variables of the isokinetic test resulted in a monofactoral structure, where peak torque (PT_{180}) and total work (W_{180}) at 180°/s showed the highest correlation (> 0.94) with the factor. The factor analysis of the dynamic variables of the CMJ on a double force platform is also monofactoral. Maximal power output (P_{max}) and Impulse (IMP) represent the factor with correlations > 0.92.
Based on these results a third factor analysis with the variables PT_{180} (peak torque at 180°/s), W_{180} (total work at 180°/s), P_{max} (maximal power output) and IMP (impulse) was performed which resulted in two independent factors (F1, F2). Factor F1 was characterized by peak torque and total work at 180°/s of the isokinetic dynamometer, and factor F2 by maximal power and impulse of the CMJ (Table 1). That means that each independent factor represents one of the test procedures.

Only low, while significant, correlations (0.32 – 0.44) between peak torque and total work at 180^o/s and maximal power output (MP) and force (MF) during CMJ where found (Table 3).

Table 2 Factorial structure of isokinetic and CMJ test variables

	Factor 1	Factor 2
IMP	0,96	0,20
P_{max}	0,96	0,20
PT_{180}	0,25	0,95
W_{180}	0,16	0,98

Table 3 Correlations between variables of each test procedure

	IMP	P_{max}
PT_{180}	0,325*	0,399**
W_{180}	0,389**	0,441**

* p < 0, 05, ** p <0,01

Only slight differences were found between the results of factor analysis of the right and leg as well as for lateral differences.

DISCUSSION

The results showed that there is only a low correlation between isokinetic and vertical jump test variables. These results can be explained by the different types of muscular action needed to execute each test and by the singular characteristics of each one of them. Finni et al. (2003) verified that there is a highly variable neuromuscular recruitment behavior between these two different motor tasks. Isokinetic dynamometry has a non functional nature, as it can isolate a special muscle and assess its dysfunction. This instrument, however, has a few limitations, since its constant angular velocities can be too low to detect training effects and since the limbs' movements are analyzed unilaterally, they represent only a low degree of similarity with most of the sport movements (Murphy & Wilson, 1997). This might also be the reason why Bennel et al. (1998) concluded that strength muscle assessment by isokinetic dynamometer during pre-season did not predict the risk of hamstring injury during the season in Australian rule football players. In contrast, vertical jumps are similar to sports movements, since numerous muscles act in multiple joints with high and variable angular velocities in order to produce the movement (Augustsson & Thomeé, 2000; Tomioka et al., 2001). Especially in several movements of soccer players strength production occurs with angular velocities higher than 300^o/s (Reilly, 2000).

Conclusion

Isokinetic dynamometry and dynamic variables of vertical jump test are highly independent test procedures. Since isokinetic dynamometry as a non functional test detects dysfunction and asymmetry of isolated muscles at constant angular velocities which does not necessarily characterize specific sport movements, it seems to be necessary to apply also functional test in order to assess muscular strength parameters during sport specific movements.

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