GENDER DIFFERENCES IN JOINT MOMENT AND POWER MEASUREMENTS DURING VERTICAL JUMP EXERCISES

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INTRODUCTION

Prior to puberty, boys and girls are quite similar in strength and power. At puberty, however, males begin a much more rapid increase in absolute strength, presumably because of increased levels of testosterone, the male sex hormone, which promotes muscular hypertrophy. Gender differences are apparent not only in the absolute maximum strength level but also in the rates at which the strength and/or power is produced (Komi & Karlsson, 1978).

Since the predominant requirement for success in a large number of athletic skills is explosive power and for the lower body this is perhaps best exemplified by vertical jump, the purpose of this study was to assess the effect of gender on the mechanical output of the lower limb joints (moments and powers), during vertical jumping exercises. Differently from other kinds of movement frequently used in functional evaluation assessments, vertical jump is a complex ballistic multi-joint action, where the musculature around the hip, knee and ankle joints collectively operate to produce patterned movements. In addition, it is a movement easy to perform and analyze in a laboratory.

METHODS

Eight male professional rugby players (age: 22.4 yr.; body mass 74.9 kg; height: 1.78 m) and eight female (age: 21.7 yr.; body mass 58.6 kg; height: 1.67 m) track and field sprinter athletes with normal lower limb function served as subjects. After a period of time in which the athletes were allowed to warm-up and became familiar with the experimental setting, each subject performed 4 series of 5 double-legged countermovement vertical jumps with the arms behind the back. Between the jumps and the series, the subjects rested 1 min and 4 min respectively. The 3-D coordinates of ten anatomical landmarks (five per leg) were detected by the optoelectronic ELITE system (Ferrigno & Pedotti, 1985) with a sampling frequency of 100 Hz. Simultaneously, the ground reaction force (GRF) signals were measured and acquired with a sampling frequency of 500 Hz. Markers were placed on sacro-iliac spines, iliac crests, great trochanters, femoral condiles, malleola, and fifth metatarsal heads to mark the pelvis and the lower limbs. Internal joint centers and the corresponding moments and powers were estimated from the position of the external landmarks and from anthropometric data by using a mathematical model designed to match feasibility with accuracy (Pedotti & Frigo, 1992). Group differences were assessed by the Wilcoxon signed-rank test. Statistical significance was assessed at $p<0.05$.

RESULTS

The mean jumping height values were 49.3 cm (sd 4.1) and 43.6 cm (sd 5.9) for men and women, respectively. The analysis of the vertical ground reaction forces

showed that the male subjects had greater peak forces and longer times of force application. The kinetic variables concerning the performance of the two groups are shown in table 1, 2, 3, and 4.
For moments, the values of men are significantly higher than those of women with a mean female-male ratio of 0.74. For powers, males displayed higher values than female with significant differences achieved only at the hip joint. The mean female-male ratio was 0.79.
When the values were normalized, dividing them by body weight and height, no significant differences were found for moments with comparable values between sexes. Considering powers, male hip values were significant higher than female ones, but females showed consistent greater values than males for knee and ankle joints. For these two latter joints, the female-male ratios were 1.30 and 1.24, respectively.
As it can be seen from the results of this study, in general, males displayed higher absolute peak moment and power values at all joints even if the amount of these differences is lower than what was found previously for other muscle actions (Colliander & Tesch, 1989). As it would be expected, when moments were normalized the differences between sexes decreased considerably. Less expected is the fact that female power corrected values were consistently higher than males at the ankle and knee joints. Two factors might explain these findings. As suggested by Komi and Bosco (1978) the women may be able to utilize the stored elastic energy to a greater extent that men when performing countermovement vertical jumps. A possible reason is that the viscoelastic properties of muscles, that contribute to eccentric force production are more developed in females than in males. The other factor is of methodological source and not gender specific. Due to their training background our female track and field sprint athletes may be in more "trained" state for vertical jump than our heavy rugby players. This is confirmed by jumping height measurements, where the average female performance was 89% of male one, a percentage greater compared to what was found in some previous works (Nelson & Martin, 1985). In addition to this, it should be considered that the duration of the training background of the present female group was longer than in the male group.

	MEN	WOMEN	RATIO
HIP	216.8±46	172.5±45	0.79*
KNEE	167.5±27	121.7±36	0.73*
ANKLE	137.1±32	96.0±35	0.70*

Table 1. Peak moments (Nm). Ratio shows female values relative to male ones. Values are mean±SD. * = significant differences between males and females.

	MEN	WOMEN	RATIO
HIP	597.8±98	314.2±65	0.52*
KNEE	553.1±105	519.0±85	0.94
ANKLE	747.4±156	689.9±132	0.92

Table 2. Peak powers (Watt). Ratio shows female values relative to male ones. Values are mean±SD. * = significant differences between males and females.

	MEN	WOMEN	RATIO
HIP	1.62±0.64	1.76±0.78	1.09
KNEE	1.25±0.41	1.25±0.65	1.00
ANKLE	1.01±0.51	0.98±0.63	0.97

Table 3. Peak moments relative to body mass and height ($Nm \cdot kg^{-1} \cdot m^{-1}$). Ratio shows female values relative to male ones. Values are mean±SD. * = significant differences between males and females.

	MEN	WOMEN	RATIO
HIP	4.49±1.47	3.22±1.24	0.72*
KNEE	4.13±1.54	5.37±1.47	1.30*
ANKLE	5.60±2.23	6.95±2.35	1.24

Table 4. Peak powers relative to body mass and height ($Watt \cdot kg^{-1} \cdot m^{-1}$). Ratio shows female values relative to male ones. Values are mean±SD. * = significant differences between males and females.

CONCLUSION

Despite the large intersubject variability observed in both groups, the test proposed here allows to point out significant gender effects on most of the examined parameters.

However, our subjects were matched for age, but not for body mass, height and physical activity backgrounds. How representative they are of the general male and female athletes population is not known and our conclusions apply only to the sample which was investigated.

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