

## Asymmetry of muscle strength in elite athletes

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### Summary

*Study aim:* To determine muscle strength variables in elite judoists and wrestlers since thigh muscle strength and bilaterally balanced flexor-to-extensor ratio minimise injury risk and are desirable for achieving sport successes.

*Material and methods:* Judoists, wrestlers and untrained subjects, 10 each, were subjected to isokinetic strength measurements of relative peak torques of knee flexor and extensor muscles on “Easy-Tech” dynamometer in concentric-concentric mode.

*Results:* Mean relative peak muscle torques for knee flexors ranged from  $1.14 \pm 0.27$  (untrained) to  $1.57 \pm 0.40$  (judoists) N·m/kg and for knee extensors from  $2.77 \pm 0.34$  (untrained) to  $3.60 \pm 0.64$  (wrestlers) N·m/kg. The flexor-to-extensor ratios ranged from  $39.3 \pm 6.0$  to  $47.8 \pm 10.8\%$  and did not differ significantly between groups. Absolute right/left asymmetry for knee flexors ranged from  $14.6 \pm 10.4$  to  $17.4 \pm 11.8\%$  and was significantly ( $p < 0.01$ ) higher than for knee extensors ( $7.2 \pm 6.8$  to  $8.6 \pm 7.7\%$ ). All asymmetry indices were significant ( $p < 0.01$ ), no significant between group differences being detected.

*Conclusions:* Implementing new training elements and modalities may improve the performance and prevent lateral asymmetry thus decreasing the risk of injuries.

**Key words:** Functional asymmetry – Muscle strength – Peak torque – Judo – Wrestling

### Introduction

The contemporary competitive combat sports are highly demanding with respect to physical fitness not only for achieving sport successes but for minimising the risk of injuries as well. During a high-intensity action in judo, the contestants are trying to throw each other on the back or to control the opponent in the ground phase [7,12]. Similarly, wrestling (Greco-Roman style) is one of the most demanding sports from a metabolic perspective, in which supreme strength and power are critical [4,9]. In both sports the strength of lower extremities is the most important one [5], therefore, maximal muscle strength and endurance are subjects of continuous monitoring, isokinetic measurements being amongst the most widely used in that respect. The aim of the study was thus to determine muscle strength variables in elite judoists and wrestlers in order to detect possible differences and similarities.

### Material and Methods

Three groups of subjects volunteered to participate in the study: 10 elite judoists, 10 elite wrestlers (Greco-

Roman style) and 10 untrained individuals. Their physical characteristics are presented in Table 1.

**Table 1.** Physical characteristics of subjects studied

	Judoists (n = 10)	Wrestlers (n = 10)	Untrained (n = 10)
Age (years)	$19.6 \pm 2.6$	$20.8 \pm 2.8$	$21.1 \pm 0.6$
Body height (cm)	$179.2 \pm 8.1$	$176.4 \pm 5.2$	$181.5 \pm 8.7$
Body mass (kg)	$82.7 \pm 19.4$	$80.1 \pm 13.9$	$79.1 \pm 11.2$
BMI	$25.6 \pm 4.0$	$25.1 \pm 2.5$	$24.0 \pm 1.8$
Training experience (years)	$9.6 \pm 2.1$	$7.9 \pm 1.0$	–

Thigh muscle strength was measured under isokinetic conditions using “Easy-Tech” dynamometer in concentric-concentric mode according to standard protocol, the subject in sitting position. Prior to every test the machine was calibrated, ROM was set at 90°, and a warm-up, consisting of bicycle run and stretching of quadriceps and hamstring muscles, applied. A more specific warm-up consisted of 3 – 4 repetitions at the testing speed (60 deg/s) for both quadriceps (knee extensor) and hamstring (knee flexor) muscles in order to prepare the

subject for regular testing. After 2 min the subjects performed 4 repetitions of maximal voluntary contractions of thigh muscles. The same person conducted all measurements and the same protocol was used for both legs [8,10].

Relative peak values of thigh muscle torques were recorded: right and left knee extensors (KE-R and KE-L, respectively), and right and left knee flexors (KF-R and KF-L, respectively). Functional asymmetry was defined as absolute lateral difference (disregarding the sign) expressed as percentage of the muscle torque of dominant side. The flexor-to-extensor ratios were computed and expressed in percentages. The data were subjected to one-way ANOVA with *post-hoc* Newmann-Keuls's test, the level of  $p \leq 0.05$  being considered significant.

**Table 2.** Mean values ( $\pm$ SD) of relative peak muscle torques of the knee joint extensors

	Judoists (n = 10)	Wrestlers * (n = 10)	Untrained (n = 10)
KE-R	3.28 $\pm$ 0.49 (2.6 – 4.0)	3.47 $\pm$ 0.51 (2.7 – 3.8)	2.87 $\pm$ 0.44 <sup>w</sup> (2.1 – 3.6)
KE -L	3.12 $\pm$ 0.50 (2.0 – 3.8)	3.60 $\pm$ 0.64 (2.7 – 4.6)	2.77 $\pm$ 0.34 <sup>jw</sup> (2.3 – 3.3)
KF-R	1.57 $\pm$ 0.40 (1.0 – 2.3)	1.36 $\pm$ 0.20 (1.1 – 1.7)	1.20 $\pm$ 0.22 <sup>j</sup> (0.9 – 1.5)
KF-L	1.41 $\pm$ 0.25 (1.2 – 2.0)	1.42 $\pm$ 0.38 (1.0 – 2.1)	1.14 $\pm$ 0.27 (0.7 – 1.6)

Legend: KE – Knee extensors; KF – Knee flexors; R – Right; L – Left; Significantly ( $p < 0.05$ ) different from wrestlers (<sup>w</sup>) or judoists (<sup>j</sup>); \* Significantly ( $p < 0.05$ ) higher than in judoists for both ratios combined

**Table 3.** Mean values ( $\pm$ SD) of flexor-to-extensor ratios (%) for right and left legs

	Judoists	Wrestlers *	Untrained
R	47.8 $\pm$ 10.8	39.5 $\pm$ 4.9	41.8 $\pm$ 5.7
L	45.9 $\pm$ 9.1	39.3 $\pm$ 6.0	41.0 $\pm$ 8.5

\* Significantly ( $p < 0.05$ ) lower than in judoists for both ratios combined

**Table 4.** Mean percent values ( $\pm$ SD) of absolute right-left asymmetry of relative peak muscle torques and of flexor-to-extensor ratios

	Judoists	Wrestlers	Untrained
KE	8.6 $\pm$ 7.7	8.4 $\pm$ 4.9	7.2 $\pm$ 6.8
KF	14.6 $\pm$ 10.4	17.4 $\pm$ 11.8	14.6 $\pm$ 11.7
KF/KE	4.06 $\pm$ 3.19	6.71 $\pm$ 3.84	5.63 $\pm$ 4.57

All individual asymmetry indices are significant ( $p < 0.01$ )

The flexor-to extensor ratios for the right and left legs combined were in wrestlers significantly lower than in judoists (Table 3). When absolute right/left differences (i.e. greater value – smaller value) between muscle torques of knee flexors or extensors were computed and

## Results

The results of muscle torque measurements for knee flexors and extensors are presented in Table 2, the ratios of flexor-to-extensor torques in Table 3 and absolute percent asymmetry indices in Table 4. Judoists and wrestlers were evidently superior to the untrained individuals with respect to peak muscle torques. No significant differences were found between wrestlers and judoists in individual muscle groups but wrestlers had significantly ( $p < 0.05$ ) higher torques of all muscle groups combined than the judoists. The values recorded in untrained subjects were lower than those in athletes but only few differences were significant (cf. Table 2).

expressed in percentages of greater (right or left) value, the resulting lateral asymmetry indices were significantly ( $p < 0.01$ ) higher for flexors than for extensors, no significant between-group differences being detected; this was also true for the asymmetry in flexor-to-extensor ratios (Table 4).

## Discussion

The lateral asymmetry in peak muscle torques may be obscured by individual dominance of the right or left leg. For that reason, mean values presented for the right and left legs may not reflect the sport-specific features. Therefore, asymmetry indices were computed; these reflected absolute right/left differences, i.e. higher of the two values had been attributed to dominance of given leg. That asymmetry, amounting to about 8 and 15% for extensors and flexors, respectively, was in all groups alike. This suggests that neither wrestling nor judo induced a more pronounced asymmetry in thigh muscle strength than that typical of untrained subjects. Thus, specific judo throwing techniques (*Uchi-mata*, *Harai-goshi*, *Osoto-gari* and *Ouchi-gari*) [2,3,6,11] and sport-related development of movement patterns proved safe regarding the risk of marked functional asymmetry. The

main difference between judo and wrestling is in the throwing technique; in wrestling, static contractions are more frequent and high absolute strength is essential in athletic performance [5]. This was reflected by significantly stronger thigh muscles (all studied muscle torques combined) in wrestlers than in judoists.

Flexor-to-extensor ratios in untrained subjects were similar to those reported by Borges [1]. Interestingly, the combined (right and left) ratios were in wrestlers significantly lower than in judoists which is suggestive of a functional dominance of flexors in judoists and of extensors in wrestlers, although no significant differences were found for muscle torques. That imbalance may be due to differences in movement patterns and types of exertions specific for both sports.

In conclusion, movement patterns in judo and wrestling are extremely demanding for thigh muscles. Thus, the training means and methods for improving strength and endurance ought to be carefully selected and adjusted. Implementing new training elements and modalities may improve the performance and prevent lateral asymmetry thus decreasing the risk of injuries.

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Received 23.10.2008

Accepted 21.02.2009

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