# THE MAXIMAL MUSCLE TORQUES DISTRIBUTION AMONG MUSCLE GROUPS IN ELITE ATHLETES IN COMBAT SPORTS

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**INTRODUCTION:** A high level of muscle strength is regarded as a prerequisite for success in many sporting activities, especially in combat sports (Janiak & Krawczyk, 1995). Maximal muscle torque measurements under static conditions have been widely used in evaluating the strength of athletes practicing diverse sports (Bucœko, 1998; Bober & Pietraszewski, 1996; Janiak & Krawczyk, 1995; Trzaskoma, Lipiñski & Janiak, 1997). The differences in strength between dominant and non-dominant legs were measured in healthy adults (Chavet, Lafortune & Gray,1997) as well as in athletes (Kramer & Balsor, 1990; Nystrom et al., 1990).
The aim of this study was to determine maximal strength and its asymmetry between dominant and non-dominant legs in elite Polish male combat sports athletes.

**METHODS AND PROCEDURES:** Three groups of elite athletes, members of the Polish National Team (11 fencers, 16 judokas and 16 boxers), took part in the experiment. The study was approved by the local Commission of Ethics. Basic characteristics of the subjects are presented in Table 1.

Table 1. Mean (± SD) values of physical characteristics of the athletes tested

| Sport | n | Age [years] | Body mass [kg] | Height [cm] |
|---|---|---|---|---|
| Boxers | 16 | 22.2 ± 2.5 | 68.7 ± 8.4 | 175.7 ± 7.1 |
| Judokas | 16 | 22.4 ± 1.4 | 79.5 ± 10.1 | 176.2 ± 7.4 |
| Fencers | 11 | 22.6 ± 4.7 | 77.1 ± 10.1 | 183.3 ± 6.9 |
| **Total** | **43** | **22.4 ± 2.9** | **74.9 ± 10.5** | **177.8 ± 7.7** |

Maximal muscle torques were measured under static conditions for flexion and extension for the elbow (EF, EE), shoulder (SF, SE), knee (KF, KE) and hip ( HF, HE) joints for the right side of the body and trunk (TF and TE, respectively). Additionally, torques of the knee and hip extension and flexion were measured for the left leg. Special torquemeter devices (chair and bench) were utilized for measurements. During measurements, the subject was stabilized in such a position that the axis of the examined joint superimposed the torquemeter axis. A detailed description of measuring devices has been reported previously (Jaszczuk et al., 1987).
The MANCOVA procedure (10 variables) was employed to test differences in average strength between sports. The logarithm of body mass was included as a covariate. The MANCOVA for repeated measures was utilized to test the asymmetry in torque distribution in the tested groups between dominant and non-

dominant legs. The Newman-Keuls test was employed to test the differences between individual averages. The Kolmogorov-Smirnov test was used to examine the distributions of the tested variables. The Pearson's correlation coefficient was utilized to test the associations between variables. The STATISTICA$^{TM}$ package was used in data processing at the significance level $\alpha$=0.05.

**RESULTS AND DISCUSSION:**

Table 2. Descriptive statistics for log-body mass [ LMASS] and muscle torques and their correlations (R) for the whole group (n=43)

| | Mean | Min | Max | SD | R |
|---|---|---|---|---|---|
| LMASS [-] | 4.31 | 4.01 | 4.58 | 0.14 | |
| EF [N m] | 88.1 | 53 | 134 | 16.3 | 0.766 |
| EE [N m] | 73.0 | 47 | 115 | 16.8 | 0.534 |
| SF [N m] | 111.9 | 72 | 161 | 20.5 | 0.409 |
| SE [N m] | 128.1 | 67 | 220 | 31.1 | 0.349 |
| KF [N m] | 136.3 | 86 | 205 | 28.2 | 0.395 |
| KE [N m] | 310.0 | 176 | 462 | 72.9 | 0.621 |
| HF [N m] | 111.2 | 62 | 157 | 26.9 | 0.693 |
| HE [N m] | 624.5 | 323 | 837 | 137.4 | 0.687 |
| TF [N m] | 185.0 | 94 | 280 | 42.9 | 0.766 |
| TE [N m] | 566.9 | 304 | 862 | 139.3 | 0.674 |

Distributions of the variables were proved normal by the Kolmogorov-Smirnov test. Since the log-body mass was statistically significantly correlated with all torque variables, the log-body mass was included in MANCOVA as a covariate. The comparison of torque values between tested groups is presented in Figure 1.

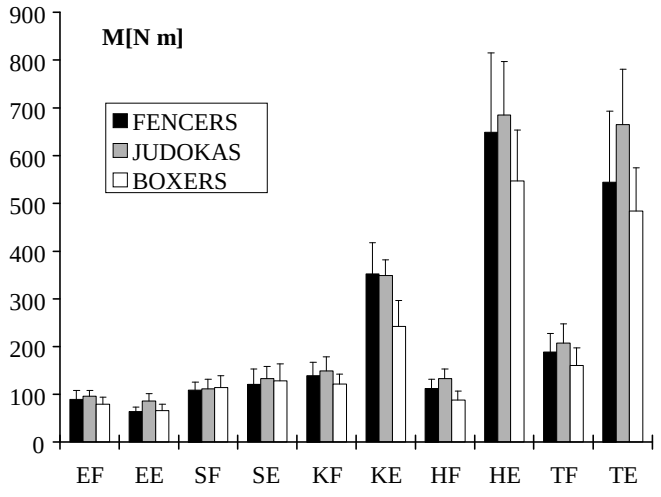


Figure 1. Comparison of mean torque values (M) for fencers (n=11), judokas (n=16),and boxers (n=16) for right extremity and trunk.

One-way MANCOVA revealed statistically significant differences in strength profiles between the disciplines studied (Rao's R=5.99, p<0.001). Generally, boxers exhibited lowest torque values. It was demonstrated using the Newman-Keuls test that muscle torques in boxers were significantly lower than corresponding ones in fencers for EF, KE, HE, HF and TF (p<0.05) and judokas for each function except SF and SE (p<0.05). The judo group attained significantly higher values than fencers for EF, HF and TE (p<0.05). Another analysis - MANCOVA for repeated measures, performed for knee end hip flexion and extension was designed to compare the strength of the dominant and non-dominant legs (SIDE effect), as well as knee and hip strength in individual sports (DISCIPLINE effect). The differences in torque symmetry between tested groups are presented in Figure 2. as the dominant-to-non-dominant leg mean torque ratios. The DISCIPLINE effect was then confirmed (Rao's R=5.89, p<0.001); however, the hypothesis about equality of mean torques of dominant and non-dominant legs in the whole group could not be rejected. On the other hand, statistically significant DISCIPLINE - SIDE interaction (Rao's r=4.19, P<0.001) suggested different types of asymmetries in the tested groups. In fact, the Newman-Keuls test revealed that HF and HE torques were significantly greater for dominant leg in fencers, while the non-dominant leg was stronger in HF for boxers.

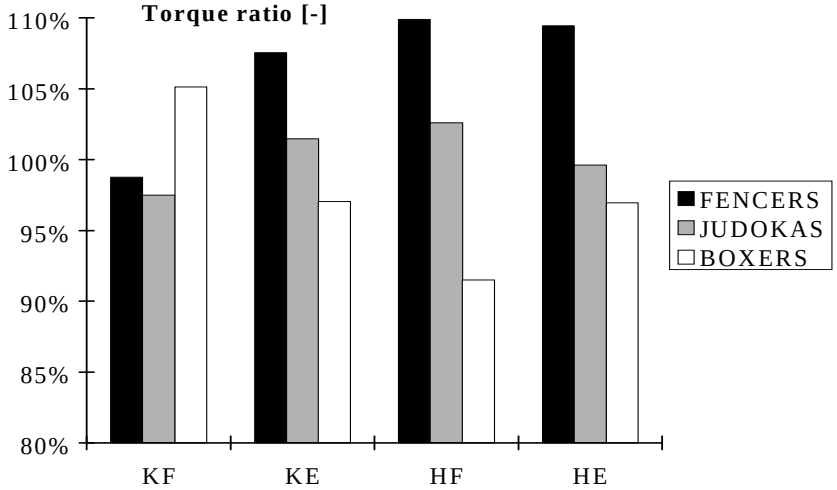

Figure 2. Mean values of the torque ratios for the dominant-to-non-dominant legs in elite athletes.

One of the laboratory indices of muscle strength is the sum of maximal torques of upper limb, trunk and lower limb muscles, but only the dominant limb was considered (Buœko, 1998; Bober & Pietraszewski, 1996; Janiak & Krawczyk, 1995). When the left and right limbs were measured separately, the sum of both was taken for the analysis (Fowler et al., 1995; Trzaskoma, Lipiñski & Janiak, 1997). For these reasons, the results of maximal muscle torques presented here can only be partially compared with those of other reports.

Higher values of muscle torques have been recorded in combat sports athletes (boxing, judo, karate, wrestling) than in those practicing other sport disciplines (Janiak & Krawczyk, 1995). As also follows from an earlier report (Janiak &

Krawczyk, 1995), boxers generated markedly lower torque values than judokas. Values of KE torque-ratio calculated for fencers were similar to those recorded in soccer players (Kramer & Balsor, 1990). It was noted that the forward leg isometric muscle strengths of epee fencers were greater than for the contralateral extremity (Nystrom et al., 1990).

A significant influence of the side of the body, as well as of sport discipline, on the asymmetry of leg strength has been demonstrated. Thus differences between fencers, judokas and boxers exist, some of which appeared to be sport-specific and related to long-term systematic training.

It was suggested that high strength asymmetry between dominant and non-dominant legs is significant with respect to performance or injury rates (Kramer & Balsor, 1990).

**CONCLUSIONS:**

- Statistically significant differences in strength and its distribution among muscle groups in the tested athletes are attributed to sport-specific factors and training.
- Imbalance in leg strength, in favor of the forward leg (dominant for fencers and non-dominant for boxers), is thought to be related to fighting position.

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