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# CHANGES OF THE MAXIMAL MUSCLE TORQUE OF MALE VOLLEYBALL PLAYERS DURING TRAINING

Summary. The aim of the study was to follow the changes of the maximal muscle torque of male volleyball players during training performed in the preparatory and starting period. Muscle torque measurements in static conditions were performed in preparatory (I, III) and starting (II, IV) periods for two years. The sum of muscle torque of the trunk and sum of muscle torque of lower extremities were decreases between I and II period, and increases between III and IV period. The sum of muscle torque of upper extremities were significantly increases between III and IV period. The significant differences between II and IV period were observed for upper extremities.

## 1. INTRODUCTION

In volleyball technical and tactical skills, anthropometrics characteristics and individual physical performance capacities are most important factors that contribute to the competitive success of a whole team. With regard to energy utilization volleyball is thought to be an aerobic sport but has high alactic anaerobic power production and long recovery periods [Häkkinen 1993, Smith et al. 1992]. Volleyball places considerable demands also on neuromuscular performance characteristics especially during the various sprints and jumps that take place repeatedly during the competitive game [Häkkinen 1993].

Training for physical fitness in volleyball takes place primarily during the preparatory training period of the season, when less emphasis is directed to training of starting drills. During the competitive season the players concentrate mainly on technical and tactical skills, while the overall volume of training for physical fitness may be greatly reduced.

The aim of the study was to follow the changes of the maximal muscle torque of male volleyball players during training performed in the preparatory and starting period.

## 2. MATERIAL AND METHOD

The study was conducted on 6 volleyball players from first league (age 28.0±5.8 years, body height 195.1±6.7 cm and body mass 93.6±12.2 kg in test I, 93.6±10.7 kg in test II, 97.0±12.2 in test III and 96.3±10.9 test IV). The protocol was approved by the Ethics Committee of Institute of Sport in Warsaw.

Muscle torque measurements in static conditions were performed for two years: twice in 2004 years (in preparatory period, 3rd September – test I and in starting period, 15th December – test II) and twice in 2005 years (in preparatory period, 28th August – test III and in starting

period, 15th December – test IV). Ten muscle groups were studied: flexors and extensors of the trunk, flexors and extensors of the shoulder, elbow, hip and knee joints.

Maximal torque of elbow, shoulder, knee, hip and trunk flexors and extensors were measured under isometric conditions on a special stand [Jaszczuk et al. 1987]. Maximal torque was measured for a single 3 s maximal voluntary contraction (MVC). The left and right limbs were measured and analysed separately. Measurements were performed at special standard positions of subjects. During measurements the subject was stabilised in such position that the axis of the examined joint superimposed the torquemeter axis. Elbow flexion and extension were performed at an angle close to 90° in elbow joint. Shoulder flexion was performed at an angle close to 50°, whereas shoulder extension at an angle close to 70° in shoulder joint. Knee flexion and extension were performed at an angle close to 90° in knee joint. Hip flexion and extension were measured with the knee and hip flexed to 90°. Trunk flexion and extension were measured with the trunk flexed to 90° (vertical position). The values of maximal torque [N·m] were recorded using special measuring set-up. Maximal values of absolute and relative (related to subject's body mass [$N \cdot m \cdot kg^{-1}$]) used for analysis. Moreover, the maximal muscle torques distribution, so-called muscle strength topography [%] were analysed, too.

ANOVA/MANOVA procedures for repeated measures were employed to data processing with *post-hoc* Scheffé test. Statistica™ v.5.5 software (StatSoft, USA) was used in data analysis.

## 3. RESULTS

Mean values (±SD) of the results are presented in table 1 and 2. No changes of the percent muscle topography of sum of upper and lower extremities were observed for two years of training (table 1). The sum of muscle torque of right and left upper extremities, right lower extremities were slightly between preparing (I) and starting (II) period. The sum of muscle torque of the trunk, left lower extremities and sum of muscle torque of ten muscle groups were decreases between I and II period (table 2). The sum of muscle torque of right and left upper extremities were significantly increases between preparing (III) and starting (IV) period. The sum of muscle torque of the trunk, lower extremities and sum of muscle torque of ten muscle groups were increases between III and IV period. No significant differences were found between I and III period. The significant differences between II and IV period were observed only for right and left upper extremities.

Table 1. Percent muscle topography (mean±SD)

| | 2004 | | 2005 | |
|---|---|---|---|---|
| | I | II | III | IV |
| UER [%] | 7.51±0.61 | 7.80±0.65 | 8.55±0.81 | 8.85±0.54 |
| UEL [%] | 7.39±0.50 | 8.21±0.65 | 7.86±1.17 | 8.20±0.77 |
| LER [%] | 31.62±2.34 | 31.35±1.73 | 31.70±1.50 | 30.76±1.14 |
| LEL [%] | 29.85±1.88 | 31.31±2.75 | 30.45±0.91 | 30.26±1.67 |
| T [%] | 23.58±2.39 | 21.33±2.66 | 21.44±2.78 | 21.94±2.18 |

Legend: UER - sum of muscle torque of right upper extremities, UEL - sum of muscle torque of left upper extremities, LER - sum of muscle torque of right lower extremities, LEL - sum of muscle torque left lower extremities, T - sum of muscle torque of the trunk;

Table 2. Mean values (±SD) of the absolute [N·m] and relative [N·m·kg$^{-1}$] muscle torque and percent differences (D) calculate between I and II or III and IV measurement

| | 2004 | | | 2005 | | |
|---|---|---|---|---|---|---|
| | I | II | D [%] | III | IV | D [%] |
| UER [N·m] | 315.2 ±49.0 | 314.2 ±42.4 | | 321.2±30.7 | 352.4±30.0$^{ab}$ | |
| [N·m·kg$^{-1}$] | 3.38±0.47 | 3.39±0.30 | 0.9 | 3.31±0.17 | 3.68±0.33$^{ab}$ | 11.2 |
| UEL [N·m] | 297.7 ±43.1 | 296.8±32.4 | | 301.3±30.5 | 336.7±31.4$^{ab}$ | |
| [N·m·kg$^{-1}$] | 3.19 ±0.33 | 3.21 ±0.19 | 1.1 | 3.13±0.37 | 3.53±0.44$^{ab}$ | 12.7 |
| LER [N·m] | 1233.0 ±85.5 | 1197.2±140.3 | | 1234.2±184.3 | 1261.2±123.3 | |
| [N·m·kg$^{-1}$] | 13.33±1.56 | 13.0±1.27 | -2.2 | 12.75±1.36 | 13.15±1.12 | 3.6 |
| LEL [N·m] | 1187.0±89.5 | 1166.4±159.0 | | 1204.2±209.3 | 1254.0±172.0 | |
| [N·m·kg$^{-1}$] | 12.85±1.69 | 12.61 ±0.98 | -11.0 | 12.41±1.58 | 13.08±1.72 | 5.6 |
| T [N·m] | 933.6±157.3 | 824.6±169.5 | | 838.0±205.3 | 900.7±161.7 | |
| [N·m·kg$^{-1}$] | 9.95±0.44 | 8.85±1.03 | -11.0 | 8.54±1.35 | 9.30±0.79 | 10.8 |
| SUM [N·m] | 3941.4±314.1 | 3784.4±502.0 | | 3805.4±648.9 | 3997.8±430.6 | |
| [N·m·kg$^{-1}$] | 42.44 ±3.27 | 40.92 ±2.74 | -3.4 | 38.89±2.73 | 41.62±2.48 | 7.3 |

Legend: UER - sum of muscle torque of right upper extremities, UEL - sum of muscle torque of left upper extremities, LER - sum of muscle torque of right lower extremities, LEL - sum of muscle torque left lower extremities, T - sum of muscle torque of the trunk, SUM - sum of muscle torque of ten muscle groups; statistically significant differences at $p<0.05$: $^{a}$ - III vs. IV, $^{b}$ - II vs. IV;

## 4. DISCUSSION

Volleyball has been described as an "interval" sport with both anaerobic and aerobic components [Smith et al. 1992], and volleyball players were classifying to athletes specializing in power events [Driss et al. 2001]. Thus the training of volleyball players should developed of strength and power output of lower extremities [Buśko 2004b]. Maximal muscle torque of the leg extensor muscles in the experimental group decreased during the preparatory and first competitive seasons in 2004 years and one increased in 2005 years but these minor changes were statistically nonsignificant. It seems that the specificity of training may have slightly interfered with maximal strength development [Buśko 2004a, Häkkinen 1988, Hickson 1980]. On the other hand, the strength training stimuli utilized were sufficient to prevent a decrease in maximal strength during the first competitive season. However, during the second starting period (IV) a significant increase took place in maximal strength, when the strength training were changed. These observations indicate the important requirement of constant high loading training stimuli in order to prevent a decrease in maximal strength. The decrease in maximal strength during complete detraining after intensive strength training is known to take place very rapidly [Häkkinen et al. 1981, Häkkinen et al. 1985]. The decreases in strength were largely individual and greater among the players who demonstrated the greatest initial strength level before the season [Häkkinen 1993]. This observation also indicates a need for a more individual programming of strength training among male athletes within a team as suggested earlier both for male [Häkkinen 1988] and female players [Häkkinen 1989].

In summary, the present findings demonstrated that the significant decrease took place in maximal strength during the preparing and competitive season in 2004 years. Strength training utilized contributed to significant increases in force production of the trained muscles during the first competitive season only in 2005 years. In volleyball players significant

increase was observed in maximal muscle torque of upper extremities. No changes of the percent muscle topography of sum of upper and lower extremities, and trunk were observed for two years of training.

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