Muscle torques of lower leg rotators in untrained subjects

Mariusz Hrycyna¹, Jacek Zieliński²

¹The Halina Konopacka University of Physical Education and Tourism, Pruszków; ²University of Physical Education, Warsaw, Poland

Summary

Study aim: To determine the relationships between muscle torques of lower leg rotators and rotation angle, and angular position at the knee joint.

Material and methods: A group of 171 untrained male subjects aged 19 – 25 years were studied. A specially designed measuring set was used. Muscle torques were determined at -30, 0 and 45º of lower leg rotation, angular positions at the knee joint being 30 or 90º.

Results: Rotation angle and angular position at the knee joint, as well as the declared laterality, significantly affected muscle torques of lower leg rotators. Highest muscle torques amounted to 55.2 ± 5.6 Nm (lower leg pronation) and 42.6 ± 7.4 Nm (lower leg supination).

Conclusions: The results may contribute to a deeper evaluation of human locomotor apparatus and to reduce the destructive forces acting on the knee joint in athletes and to improve monitoring the functions of reconstructed knee joint in rehabilitees.

Key words: Muscle torques – Knee joint – Rotation

Introduction

Muscle mechanics, including the maximum attainable muscle torques have been extensively studied [1,11] due to the need to determine the fitness of athletes which is crucial for achieving high sport results [6,14]. Determining motion ranges and muscle torques is essential for assessing the functional status of the locomotor system not only in sports but in e.g. rehabilitation monitoring [2,12,13]. Those procedures may also be useful in analysing movement techniques, including the elimination of movements potentially hazardous for the joints.

With respect to the knee joint, most studies pertained to the functions of flexors and extensors, the rotators being of marginal interest. Considering the fact that knee joint is the most prone to injuries [8], it seems that all kinds of muscles deserve thorough investigation. Thus, the aim of this paper was to determine muscle torques of lower leg rotators in relation to the angular position at the knee joint and to the rotation angle, especially to its extreme values, at which the knee joint is most prone to injuries. Further, the pronation-to-supination relation of rotator muscle torques and the effects of the declared manipulative domination of lower extremities seemed of importance.

Material and Methods

Subjects: A group of 171 untrained male university students aged 19 – 25 years were studied. They were not engaged in competitive sports and experienced no serious knee injuries. They declared to be right- or left-legged (n = 141 and 30, respectively) and were subsequently classified according to the dominating leg. The study was approved by the local Committee of Ethics.

Methodology: A specially designed measuring stand (Fig. 2) was used to measure muscle torques of lower leg rotators; special attention was put on rigidly stabilising the trunk, thigh and foot. The thigh was stabilised at two points in order to eliminate rotations at the hip joint. The trunk and hip were stabilised with clamping rings and belts, two clamping rings and a belt were applied to the foot to prevent any movement at the ankle joint.

The following axial positions at the knee joint were used, based on literature [7] and pilot trials: 30º of inward position (Fig. 1 left; one measurement in outward rotation), 0º (two measurements – inward and outward rotations) and 45º of outward position (one measurement in inward rotation); all at two angular positions at the knee joint flexion: 30 and 90º (straight leg – 0º).
Muscle torques of lower leg rotators

Fig. 1. Angular positions at the knee joint (-30, 0 and 45°, respectively)

Fig. 2. Measuring stand for determining muscle torques of lower leg rotators
Legend: HS – Hip stabilisers; TS – Thigh stabilisers; FS – Foot stabilisers; TM – Torque meter; SR – Shank rotation adjustment; AL – Station arm length adjustment; KP – Knee angular position adjustment; AH – Station arm height adjustment; HB – Hip belt

The results, after having been classified into the dominating or non-dominating legs as declared by the subjects, were subjected to two-way ANOVA followed by the post-hoc Student’s t-test for dependent data. The level of p≤0.05 was considered significant.

Results

The results are presented in Table 1 and in Figs. 3 and 4. In Table 1 are shown mean values (±SD) of anthropometric variables recorded for the dominating leg and for the difference between dominating and non-dominating legs.

Highest rotator muscle torques were recorded for the dominating leg at outward position 45° (pronation) in both knee positions, i.e. 30 and 90°, the torques amounting to 55.2 ± 5.6 and 52.4 ± 6.0 Nm, respectively. In the centred position (0°) lowest values were noted, the differences between inward and outward rotations being highly variable. Highest absolute difference amounted to 28 Nm, i.e. about 50% of the maximum mean value.

Table 1. Mean values (±SD) of anthropometric variables recorded for the dominating leg and for the difference between dominating and non-dominating legs in young, untrained male subjects (n = 171)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Means ±SD</th>
</tr>
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<tbody>
<tr>
<td>Age (years)</td>
<td>21.4 ± 1.9</td>
</tr>
<tr>
<td>Body height (cm)</td>
<td>179.3 ± 5.8</td>
</tr>
<tr>
<td>Body mass (kg)</td>
<td>77.8 ± 6.0</td>
</tr>
<tr>
<td>Thigh length (cm)</td>
<td>42.4 ± 2.3</td>
</tr>
<tr>
<td>Thigh girth (cm)</td>
<td>56.8 ± 3.7</td>
</tr>
<tr>
<td>Lower leg length (cm)</td>
<td>43.3 ± 2.2</td>
</tr>
<tr>
<td>Calf girth (cm)</td>
<td>37.3 ± 2.1</td>
</tr>
<tr>
<td>Knee width (cm)</td>
<td>10.0 ± 0.5</td>
</tr>
</tbody>
</table>

Fig. 3. Mean values (±SD) of muscle torques of lower leg rotators of the dominating leg at two angular flexions at the knee joint (30 and 90°) recorded in young, untrained male subjects (n = 171)
Legend: P – Pronation; S – Supination; The accompanying numbers are rotation angles; All values recorded at 30° significantly (p<0.001) differ from the respective ones at 90°; *** Significant (p<0.001) difference between inward (S) and outward (P) rotations at 0°
ANOVA revealed significant interaction between knee flexion angle and inward/outward rotations, thus all corresponding means were compared and proved significantly (p<0.001) different. Correlations of muscle torques with body mass were significant but low and ranged from r = 0.26 to 0.37.

Mean differences between values for the dominating and non-dominating legs are shown in Fig. 4. The non-dominating leg was, on average, by 1 - Nm weaker from the dominant one in all cases except outward position (pronation) in both knee flexion positions. Those values were relatively alike, only those for outward position at 45º significantly differed from those at 0º (p<0.001 for 30º and p<0.05 for 90º).

Discussion

The effects of angular position at given joint on muscle torques were reported [5,9], thus the existence of optimum flexion angle at the knee joint for maximum muscle torque of lower leg rotators could be assumed. Inasmuch only few angular positions were examined in this study, highest rotator muscle torques were recorded for knee angle equal to 75º [9]. Also other authors [15] reported that angular position at the hip joint (0 or 90º) had no effect on muscle torques of knee extensors in women, the knee angle amounting to 90º. Since most of the lower leg rotators are biarticular, their principal function being knee flexion, changes in angular position at the hip joint affect muscle length and their torques.

Muscle torques of knee flexors or extensors are severalfold higher than those of lower leg rotators. At knee position equal to 90º, muscle torques of knee extensors and flexors average 281 and 190 Nm, respectively [4], and of rotators – about 52 Nm. That big difference is due to different muscle functions; leg movements in the sagittal plane are under the load of the entire body mass while lower leg rotations are under the load of the mass of lower leg and foot which amounts to about 7% of total body mass [3]. Lower leg rotators are thus chiefly responsible for an active stabilisation of the knee joint and protect ligaments, especially the cruciate one, from damages. Muscle torques in inward rotation were by about 20% lower than in the inward lower leg rotation which could be due to differences in the numbers of muscles engaged in those movements.

Some authors [10] found no significant correlation between muscle torques of knee flexors and extensors and body mass, others [4] confirmed that for extensors only, the correlation coefficient for flexors amounting to 0.44. The respective correlation coefficients for rotator muscles found in this study, not exceeding the value of 0.37, were relatively high considering the fact that the loads in lower leg rotation amount to only 7% of body mass. It was also demonstrated that leg lateralisation had a significant effect on rotator muscle torques.

In conclusion, the results may contribute to a deeper evaluation of human locomotor apparatus and to reduce the destructive forces acting on the knee joint in athletes (e.g. in football or handball). The results may also contribute to improve monitoring the functions of the knee joint in rehabilitees since shaping the thigh girth or recovery from deep sensory disorders are not sufficient in preventing future injuries of that joint.

References


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