Introduction

The knee joint is the largest joint of the human body. During an improper movement it is affected by considerable forces [1] which can often exert a destructive influence on the knee internal structure [2]. In the domain of professional sports, ruptured knee ligaments occur quite frequently [3], especially the anterior cruciate ligament (ACL). Differences between active axial rotation and muscular strength of rotators in the healthy and post-traumatic knee joints of 40 hospitalized patients were examined. Basic procedures. The static torque evaluation of the shank rotating muscles included 40 patients of the Endoscopic Surgery Clinic in Zory, with the ruptured ACL of the right knee, qualified for surgery (ACL reconstruction). On the basis of a medical interview, the ACL ruptures were found to have occurred during football games. Main findings. ACL damage leads to an increased rotation range, with a subsequent decrease of the rotators’ strength and increased joint instability. The patients examined showed a substantial level of thigh quadriceps atrophy – a typical symptom associated with an ACL rupture. Our findings indicate that the internal and external rotators in intact knees were stronger than the rotators in post-traumatic knees \( p < 0.05 \). Conclusions. The analysis of the torque of the shank rotating muscles at two knee joint flexion angles was an attempt to proceed with a laboratory diagnosis of the condition of the motor system in 40 patients following severe trauma (such as the ACL rupture of the right knee) prior to surgical intervention, and, in a longer perspective, after treatment completion. The results obtained will supposedly be useful as indicators for future rehabilitation pathways, and of the condition of the motor system following treatment completion.

Key words: knee, rotator, axial, anterior cruciate ligament
to compare the torques of muscles responsible for internal and external rotation of a healthy and post-traumatic knee joint (patients and control group);

- to analyze differences in anthropometric parameters of the lower extremities in patients under study (differences in the circumference of the right and the left thigh at rest).

**Material and methods**

The study sample consisted of 40 patients from the Endoscopic Surgery Clinic in Zory, Poland. The clinical diagnosis revealed an ACL rupture of the right knee in all the patients owing to a football injury. All patients were awaiting surgery, i.e. reconstruction of the anterior cruciate ligament.

| Age (years) | Body height (cm) | Body weight (kg) |
|-------------|------------------|------------------|
| \(\bar{x}\) 27.36 | 177.86 | 79.25 |
| SD 8.11 | 4.72 | 12.26 |

The control group consisted of 100 healthy, non-training first-year full time students from the University School of Physical Education. Their level of physical fitness was higher than average, which is typical of physical education students.

| Age (years) | Body height (cm) | Body weight (kg) |
|-------------|------------------|------------------|
| \(\bar{x}\) 21.33 | 175.8 | 72.5 |
| SD 6.1 | 3.2 | 8.4 |

Active rotation was defined as maximal “rotation” of the shank with the use of subject’s muscle strength (Fig. 1).

The peak torque of the shank pronation and supination was measured in static conditions using a specially designed testing station (Fig. 2) connected to a PC with the CPS/HMF software package allowing registration of torque development in the shank rotating muscles.

The torque measurements of shank rotating muscles were carried out at the flexion angles of 30° and 90°, respectively (Fig. 3).
For each subject under study the following adjustments were made:
- hip, thigh and foot stabilizers;
- height of the station rotational axis corresponding to the knee axis of rotation;
- length of the station arm corresponding to the length of shank and thigh;
- knee flexion angle;
- shank rotation angle.

During the measurement of torques of shank rotators the following angles were considered:

1. 0° – vertical foot position – the shank rotates inside (pronates), rests and rotates outside (supinates) (shank position: \( p_{00}, s_{00} \));

2. 40° – turned foot position – the shank rotates inside (pronates) (shank position: \( p_{400} \));

3. 30° – turned foot position – the shank rotates outside (supinates) (shank position: \( s_{300} \));

Table 3 presents the results of measurements of torques of rotating muscles in healthy and post-traumatic knee joints in the group of patients and the control group. In the statistical analysis of these results the arithmetic means and standard deviations were calculated (Tab. 3, Fig. 7). In order to compare the measurements at different shank angular positions (for pronation and supination) analysis of variance (ANOVA) was used. The level of statistical significance of differences between respective measurements was estimated with Duncan’s test (\( p < 0.05 \)).

Discussion

The results obtained reveal an increase in the range of active internal and external rotation in the post-traumatic knee joint (Fig. 1). This makes the force of pronating and supinating muscles decrease, which is a typical symptom associated with this knee joint injuries. The obtained shank torque values point to statis-
M. Popieluch, J. Zieliński, M. Jędrysik, Torque of muscles rotating the knee joint

Figure 7. Torque values of rotating muscles in the patients’ healthy (left) and post-traumatic (right) knee joints

Typically significant differences between the post-traumatic leg (right) and healthy leg (left) \(p < 0.05\). The rotating muscles in the knee joint with the ruptured ACL developed significantly lower torque values than muscles in the knee joint with the healthy ligament (about 30%).

Figure 7 presents the torque values of shank rotators in the group of patients. The subjects achieved significantly higher torques at the knee flexion angle of 90° amounting to about 40–50 Nm. In the control group these values were significantly higher amounting to over 70 Nm (in some cases the torque value difference between the patients and the control group was even 50%) (Tab. 3). The measurement of the circumference of the right and left thigh in the patients revealed a decreasing tendency in the circumference of the post-traumatic thigh, which is indicative of thigh quadriceps atrophy. This is due to patients’ “subconscious saving” of the post-traumatic leg before surgery.

The results obtained are difficult to compare with results of other studies, as similar tests are usually carried out in isokinetic conditions. It is also difficult to compare the knee muscle torque values obtained in static conditions with isokinetic results. However, the question of rotating movements attracts considerable research interest, and future studies of the strength capacities of rotating muscles (involving earlier determination of biomechanical capacities of knee flexors and extensors) will definitely contribute to a comprehensive assessment of the function of the whole knee joint.

Conclusions

1. The present research is an attempt to evaluate the efficiency of the lower extremity (on the example of knee joint) following a severe trauma and before surgery and – in a longer perspective – after treatment completion. The obtained results can be used as important additional information in therapy documentation and for rehabilitation purposes.

2. A rupture of the anterior cruciate ligament leads to a disruption of knee movements and instability of the knee joint (anterior dislocation of the tibia).

3. An ACL rupture increases the range of shank rotation, reduces the strength of the pronators and supinators, and increases the knee joint instability.

4. Significant thigh quadriceps atrophy was observed in patients under study, which is a typical symptom associated with the ACL rupture.
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