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The selection of a position for the measurement of an ankle joint muscle torques*

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The influence of different segmental positions during ankle joint static flexion with maximal voluntary contraction on the value of the muscle torques was examined. Twelve male subjects, aged between 25 and 40 years performed trials in three various positions: standing (position 1), sitting with an active leg extended horizontally (position 2), sitting with both legs flexed at 90° angles in knee and hip joints (position 3). All tests were performed using the constructed electro-mechanical device. It follows from the analysis of the results that position 3 is the most suitable for measuring of muscle torques during ankle joint static flexion.

Key words: Strenght measurement — Plantar flexors — Maximal contrations — Static conditions

Introduction

The muscle torques of an ankle joint have been measured by many authors [1, 2, 3, 5]. An example of a device constructed for the measurement of force developed in an ankle joint is given in [5] (Fig. 1). Subject, lying on a stomach, presses tested foot against the resistance plate, thus causing the expansion of a tensometric ring and changing the resistance of the sensors and the voltage of the circuit. In papers [1, 2] another measurement device is described (Fig. 2) with different position of a subject, but the idea of measurement the same as the one given in [5]. Various sets described by number of authors differ mainly in

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regard to the subject's during the measurement. This position may significantly influence the results obtained.

The purpose of this study was to determine the optimal position for the measurement of an ankle joint torques, and to construct an adequate measuring device.

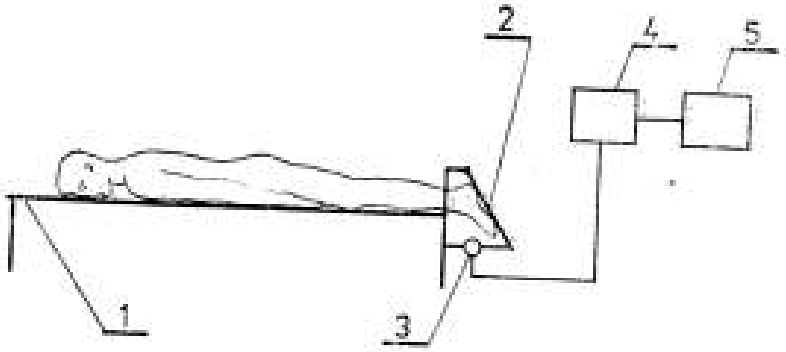

Fig. 1. Schematic representation of the experimental set-up for the moment of force measurement during ankle joint flexion [5], 1 — medical table, 2 — foot stabilizer, 3 — force transducer, 4 — bridge amplifier, 5 — voltmeter

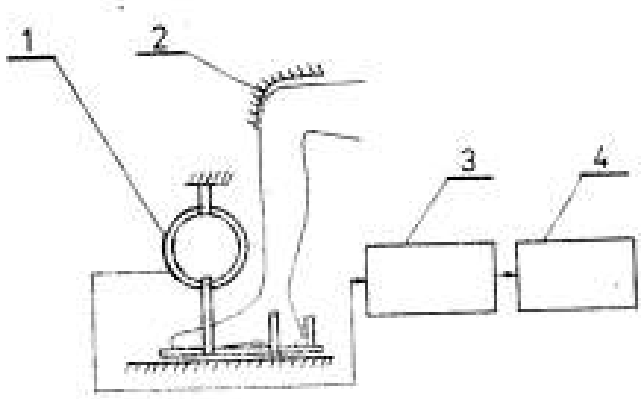

Fig. 2. Schematic representation of the experimental set-up for the moment of force measurement during ankle joint flexion [2], 1 — force transducer, 2 —stabilizer, 3 — bridge amplifier, 4 — voltmeter

Material and methods

The subject of this work were 12 men. Mean values (± standard deviation) of age, body mass, and height in the group were 34 ± 2 years, 71. ± 2.6 kg, and 175.6 ± 1.9 cm, respectively.

The set was build to measure the force generated by flexors of an ankle joint in static conditions. It consists of a base (1), a pedal (2), and a tensometric ring (3) (Fig. 3). The measuring pedal (2) is mounted on a bearing which allows for the rotation about the x-x axis. The

tensometric ring (3), being a force sensor, is placed at the present distance from this axis and works as a torque meter.

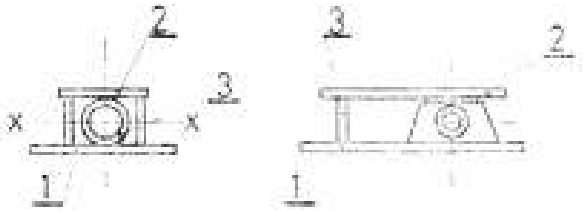

Fig. 3. Schematic outline of the model set-up for the moment of force measurement

There were three options studied, connected with different positions of a subject:

— position 1 — standing (Fig. 4)

— position 2 — sitting, tested leg extended in the knee joint (Fig. 5),

— position 3 — sitting, bith legs flexed with angles in the knee and the hip jaint equal 90° (Fig. 6).

Fig. 4. The moment of force measurement in standing position

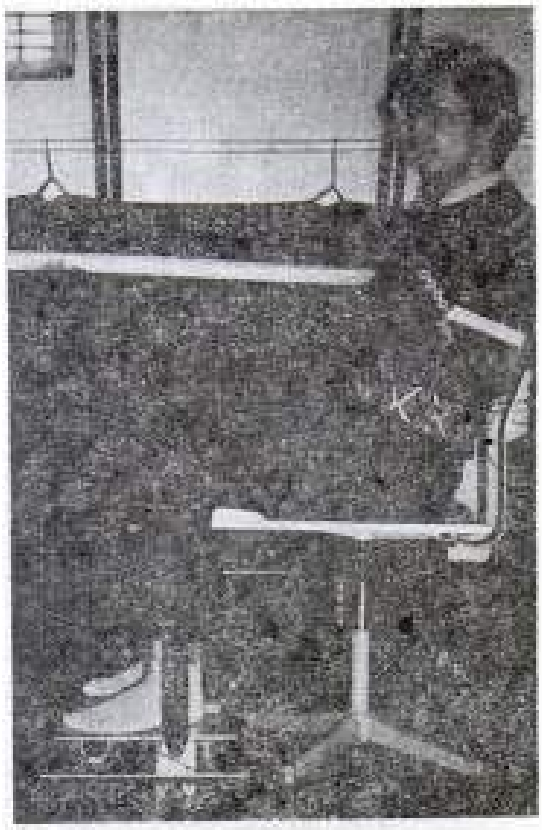

Fig. 5. The moment of force measurement in sitting position with lower limb placed verticaly

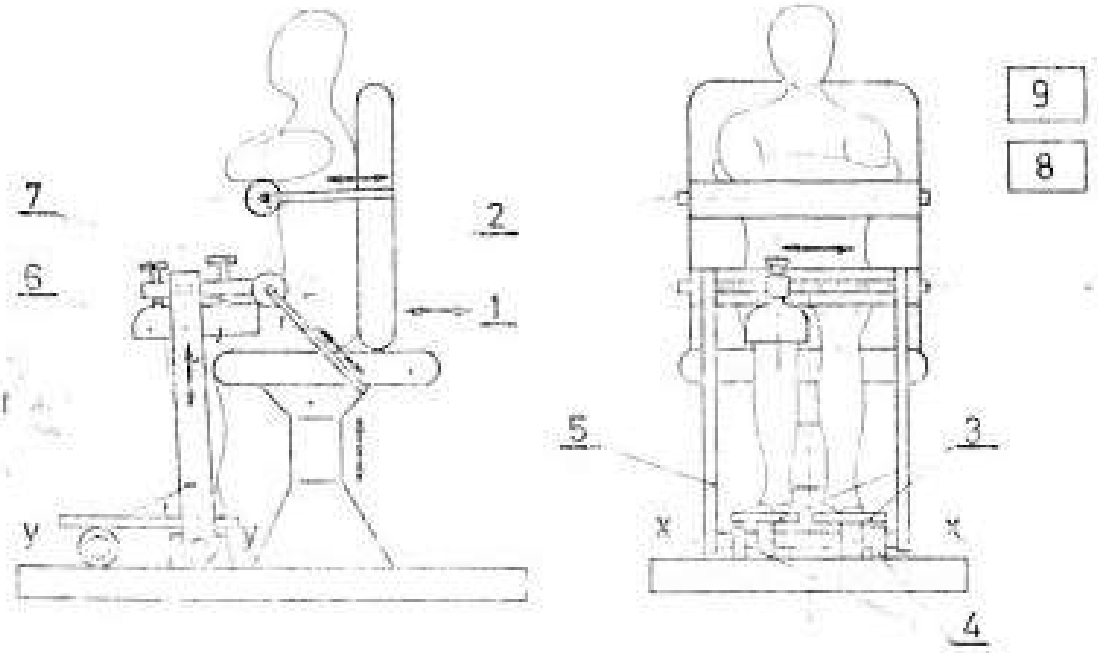

Fig. 6. Schematic outline of the experimental set-up for the moment of force measurement during ankle joint flexion

Results and discussion

Mean values and standard deviations of the results are given in tab. 1. The significance of the differences between the mean values was tested by means of an adequate t-test (chosen on the basis of a F-test for the significance of the differences between variances) [4]. The results are shown in tab. 1. Variance of the results obtained for position 3 was significantly different from those obtained for positions 1 and 2, while the mean values did not differ significantly. The opposite relation was observed for the other cases. The lowest values of variance were found for position 3. Biomechanical analysis of the tested positions reveled that stabilization as well as the method of measurement do influence the results. In position 1 (standing) some additional muscle torques are developed and transmitted. These torques originate from biokinematical chain consisted of spine, shoulders, upper limb, and grip (the effect of spine elongation and lifting of shoulders). In position 2 (sitting with the tested leg extended) the muscle torques of trunk and hip extensors can also be transmitted. Moreover, maximal activation of the triceps muscle of a calf causes the development of the forces flexing the knee joint (knee joint flexor) and stimulate so-called absolute synergism (incorporation of the two-joint muscles: flexors of a knee joint and extensors of a hip joint). This, in turn, makes the heel leave the resistance plate and transfers on it the torque of a whole kinematic chain.

Table 1

Mean values and standard deviations of moments of force (M_n) measured in three positions: (1), (2), (3) for right lower limb (rll) and left lower limb (lll). For father details see text

Position		1	2	3
n=12		$\bar{s} \pm sd$	$\bar{s} \pm sd$	$\bar{s} \pm sd$
lll	[Nm]	187 ± 36	232 ± 43*	163 ± 26*!
rll	[Nm]	185 ± 41	219 ± 44*	163 ± 23w

* significant difference of mean values ($p<0.01$) between positions (1) and (2), and positions (1) and (3),

! significant difference of mean values ($p<0.01$) between positions (2) and (3),

w significant difference of variations ($p<0.05$) between positions (2) and (1), and positions (3) and (2).

Stabilization of a tested leg proved to be very difficult. Too large stabilizing forces caused the soreness of a tested joint, whereas the forces of low values did not exclude all the negative phenomena. It seems that in position 3 all the above faults are eliminated. The results of this

study are similar to those obtained in the tests using the measuring set with the same position of a subject (Fig. 2, unpublished data).

On the basis of the preliminary test's results it was decided to choose position 3 as the most comfortable and the best for measurement of the muscle torques developed on an ankle joint.

Description of the measuring set construction and of the measurement technique

1. Construction

The set consists of two main systems.

a) stabilizing
b) measuring

The block diagram of the set is shown in Fig. 7.
The stabilizing system constitutes of a seat (1), shafts (2), and a thigh clasp (6). The position of a seat can be regulated vertically, and the positions of a seat and a back-rest — horizontally. This regulation is performed using the hydraulic servo-motors. Stabilizing shafts ensure the proper position of a body, acting on the subject's chest and waist. The stabilizing clasp is mounted on a bearing which allows for the rotation about the x-x axis. The range of stabilization can be regulated in relation to the length of a calf. The clasp is pressed against the thigh and fixed by two screws. Coaxial maunting of the clasp and the measuring pedal ensures the elimination of the stabilization's influence on the result of a measurement.

The measuring system is bulit of the pedals equipped with a force sensor (4), an amplifier (8), and a meter (9). The pedal can rotate about the x-x axis. The force sensor is a strain gauge ring mounted at the fixed distance from the axis and works as a torque meter. Pedals as well as the stabilizing clasp can be gradually moved in a vertical plane.

2. Measurement technique

The set enables the measurement of a torque developed by the flexors of a foot in static conditions. The subject is sitting on the seat with hip, knee, and ankle joint angles equal 90°. The rotation axis of the measured joint is placed exactly above the x-x axis. The position of a subject can be assured by the adjustment of the seat, the back-rest, the clasp, and the pedals. The stabilization is performed by pressing down and locking of the stabilizing shafts and of the thigh clasp. The value of a measured torque is digitally displayed on the meter. Shifting of the clasp enables the measurement of both legs (left as well as right).

Conclusion

The most suitable position for the measurement of an ankle joint muscles torques is the sitting position with the angles in both hip and knee joints equal 90° and with a proper stabilization of a leg.

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Stre zczenie

W pracy tej podjęto próbę określenia wpływu pozycji pomiarowej na wyniki pomiarów momentów sił w stawie skokowo-goleniowym oraz skonstruowano stanowisko modelowe do ich pomiarów. Badania przeprowadzono w Instytucie Sportu na 12 mężczyznach. Mierzono momenty sił w pozycjach: stojąc (pozycja 1), siad z mierzoną kończyną dolną wyprostowaną w stawie kolanowym (pozycja 2) oraz siad na krześle, kończyny dolne zgięte w stawach kolanowych i biodrowych pod kątem prostym (pozycja 3). W wyniku przeprowadzonej analizy rezultatów badań stwierdzono, że najodpowiedniejszą pozycją pomiarową jest pozycja 3 — siad na krześle, kończyny dolne zgięte w stawach kolanowych i biodrowych pod kątem prostym. Skonstruowano stanowisko pomiarowe umożliwiające pomiar w tej pozycji.

Резюме

В работе занимались попыткой определения влияния разных положений тела на величину измеряемых мышечных моментов сил (М) в голенно—стопном суставе. Измерения проводились с помощью сделанной нами установки. Исследования были осуществены в Институте Спорта на 12 мужчинах. Измерялись мышечные моменты сил во время:

— вертикальной стойки (1)
— сидя с выпрямленной ногой (2)
— сидя в кресле (3)

Принимая позу (3) испытуемые розвивали самые малые моменты сил (М), а рассеяние величин (М) было минимальное.