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Brief report

Reliability of a new, hand-held device for assessing skeletal muscle stiffness

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Abstract

Objective. The aim of the study was to examine the test–retest reliability of the Myoton-2 myometer for measuring skeletal muscle viscoelastic stiffness.

Methods. Ten healthy volunteers took part. On day 1, the viscoelastic stiffness of the rectus femoris, vastus lateralis, biceps femoris, and gastrocnemius muscle (lateral and medial heads) was measured at rest using the Myoton-2 myometer. On day 2, the tests were repeated, and the rectus femoris was also examined during the maintenance of submaximal contractions of the quadriceps, and at a different resting muscle length.

Results. The myometer showed good to excellent test–retest reliability for all muscles (ICCs 0.80-0.93), except for the vastus lateralis (ICC 0.40). Viscoelastic stiffness showed a linear increase with increasing quadriceps' force output, and was higher in stretched than in shortened resting muscle.

Conclusion. The Myoton-2 myometer is a reliable device for measuring the viscoelastic stiffness of resting muscle. Furthermore, viscoelastic stiffness showed the expected changes in response to increases in force output and muscle length, suggesting that the measurements were also valid.

Relevance

Theresults of this pilot study show that the Myoton-2 myometer is a simple, precise instrument for measuring muscle viscoelastic stiffness. If the findings can be confirmed in larger studies, further research should be carried out to examine its potential applications in the field of musculoskeletal medicine.

Keywords: Skeletal muscle; Viscoelastic stiffness; Measurement; Myometry

1. Introduction

Abnormalities in muscle stiffness are a common feature of a number of neurological disorders and are also observed in connection with various work- and sports-related overuse or overtraining syndromes (Mense and Simons, 2001; Renstrom and Johnson, 1985). The aim of the present pilot study was to investigate the reliability of a recently developed, hand-held "myometer" for measuring skeletal muscle viscoelastic stiffness.

2. Methods

2.1. Test volunteers

10 volunteers (five male, five female), mean age 40 (SD 13) years, with no known muscular or neuromuscular disorders, took part.

2.2. Instrumentation

Bilateral measurements of viscoelastic stiffness of the vastus lateralis, rectus femoris, and lateral and medial gastrocnemius muscles were carried out at rest, using the myometer (Myoton-2), on two consecutive days. Briefly (see Veldi et al., 2002 for full details), the myometer works as follows. The testing end is placed on and perpendicular to the surface of the skin overlying the

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muscle of interest. Slight pressure is exerted on the underlying soft tissues by the weight of the testing end, lightly compressing the tissues. By means of a switch, the electromagnet of the device produces a short (few milliseconds) constant force impulse, which is forwarded via the testing end to the contact area. This causes the tissue under the probe to be deformed for a short, predetermined period of time. Upon withdrawal of the current to the electromagnet, the testing end is quickly released, after which the muscle together with the testing end performs damped natural oscillations, governed by the viscoelastic properties of the biological tissue. An acceleration-transducer situated on the testing end allows recording of the muscle deformation characteristics. At the point of maximum compression of the muscle under investigation, the corresponding acceleration $a_{\max}$ characterises the resistance force of the tissue (force $= ma_{\max}$, where m is the mass of the testing end) for the known deformation depth Δl. The ratio $ma_{\max}/\Delta l$ describes the viscoelastic stiffness of the tissue.

2.3. Procedures

During the tests, the subject lay relaxed on an examination couch. For measurement of the anterior muscles, the subject lay supine with the knees slightly flexed and supported by a cushion underneath. For the posterior muscles, a prone position was adopted. The sites for measurement (in the middle of the muscle belly) were identified by manual palpation. Twenty consecutive measurements (with a time interval of 1 s between each) were made at each site, and the average value was used for further analysis. On day 2, the sites were identified anew and the measurements repeated exactly as on day 1. In addition, measurements were made from the right and left rectus femoris muscles, during short (3–5 s) submaximal contractions of the knee extensors at 20%, 40% 60% and 80% of the previously determined maximum voluntary contraction (MVC) (with 1–2 min rest between contractions). During these measurements, the patient remained supine but with the knee flexed to 90° and the lower leg hanging over the end of the couch. The MVC and the submaximal forces were registered by a spring balance attached to a strap around the ankle (above the lateral malleolus) and running parallel to the ground. Feedback regarding the force level was given by the investigator. Resting measurements made in this same test position, prior to the submaximal contractions, allowed determination of the viscoelastic stiffness of the lengthened rectus femoris muscle.

3. Data analysis

A repeated measures ANOVA followed by determination of the intraclass correlation coefficient (ICC) was used to determine reliability.

4. Results

With the exception of the left vastus lateralis, there was no significant difference between the group mean values for viscoelastic stiffness on day 1 and day 2 for any of the individual muscles and the ICCs were good to excellent, ranging from 0.80 to 0.93 (Table 1). Within-day comparisons for each of the variables revealed as good or even higher ICCs, with no significant differences between the mean values for each muscle. Viscoelastic stiffness showed an approximately linear increase with increasing force output (average Pearson correlation coefficient for all subjects, $r = 0.86$ (range 0.47–0.99).

Table 1
Group mean and SD values of muscle stiffness; the significance of the difference between the mean values; and the intraclass correlation coefficient (ICC) for the repeated measures

Muscle site	Side	Stiffness (N m^{-1})					
		Day 1		Day 2		Day 1 vs 2	Day 1 vs 2
		Mean	SD	Mean	SD	*P* value	ICC
Biceps Fem.	Right	258.8	35.1	255.0	49.8	0.59	0.80
	Left	258.2	30.2	252.8	38.6	0.27	0.91
Vastus Lat.	Right	253.4	21.2	243.8	19.5	0.21	0.40
	Left	255.5	22.7	245.5	22.4	0.01*	0.93
Rectus Fem.	Right	267.7	31.4	270.9	34.2	0.58	0.85
	Left	264.8	32.8	256.4	32.7	0.19	0.84
Gastroc Med.	Right	244.2	26.3	235.6	26.9	0.14	0.80
	Left	247.4	30.9	241.0	23.6	0.17	0.88
Gastroc Lat.	Right	249.5	25.3	249.5	27.9	0.99	0.86
	Left	253.3	27.4	257.2	25.1	0.23	0.93

* $P < 0.05$ = significant difference, day 1 vs day 2 (paired *t*-test).

There was a significant increase in resting viscoelastic stiffness of the rectus femoris in the lengthened position (from 266 ± 34 N m^{-1} (mean of $R + L$, shortened) to 317 ± 47 N m^{-1} (mean of $R + L$, lengthened); $P < 0.001$).

5. Discussion

In general, the myometer recorded very consistent and reliable measurements of muscle viscoelastic stiffness. The poorer results with vastus lateralis were believed to be the result of the difficulty in positioning the myometer vertically and still perpendicular to the surface of this muscle. The linear relationship with force output suggested that the device was giving a valid recording of the viscoleastic stiffness of the muscle rather than that of the subcutaneous tissue. The increased viscoelastic stiffness of the lengthened rectus femoris indicated the sensitivity of the device to expected changes in the muscles' mechanical properties with changes in length. If the findings of this pilot study can be replicated in larger groups of individuals, further research is warranted to examine potential applications of the myometer in the field of musculoskeletal medicine. Such applications might include the monitoring of: the effectiveness of drug treatments (e.g. muscle relaxants, in connection with disorders such as myofascial syndrome or spasticity) and of physiotherapy (e.g. massage, stretching, relaxation therapy/EMG biofeedback); the effects of immobilization/disuse; and the readiness for resumption of sporting activities following "over-training".

In conclusion, these initial results suggest that the myometer is a reliable device for measuring skeletal muscle viscoelastic stiffness. Further studies are required to verify the findings in a larger group of subjects and to examine potential applications of the device in physical medicine.

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