Validity & Reliability of Tensiomyography

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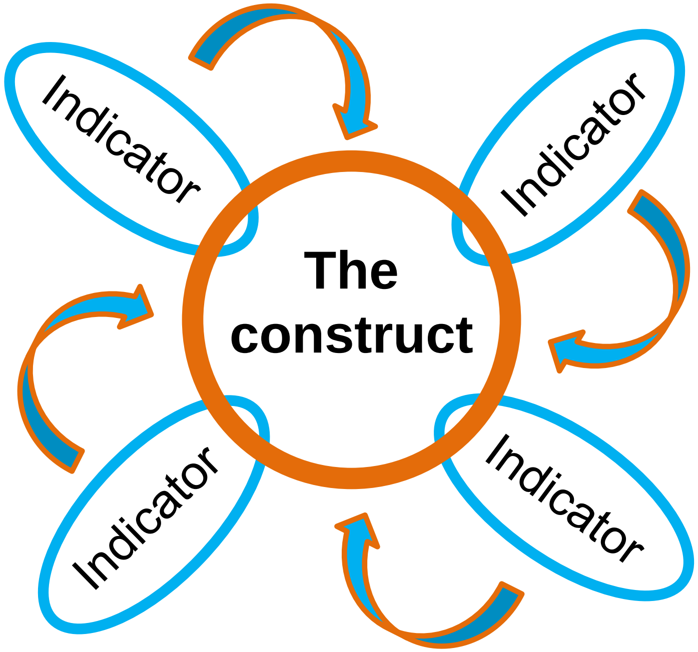
An Coláiste Ollscoile, Baile Átha Cliath

Definition of validity

- Criterion (concurrent) validity
- Construct validity



Artificial Organs
21(3):240–242, Blackwell Science, Inc., Boston

Measuring of Skeletal Muscles' Dynamic Properties

Vojko Valenčič and Nataša Knez

Faculty of Electrical Engineering, University of Ljubljana, Ljubljana, Slovenia

N = 1 (male, age 25 yr)

Muscles:

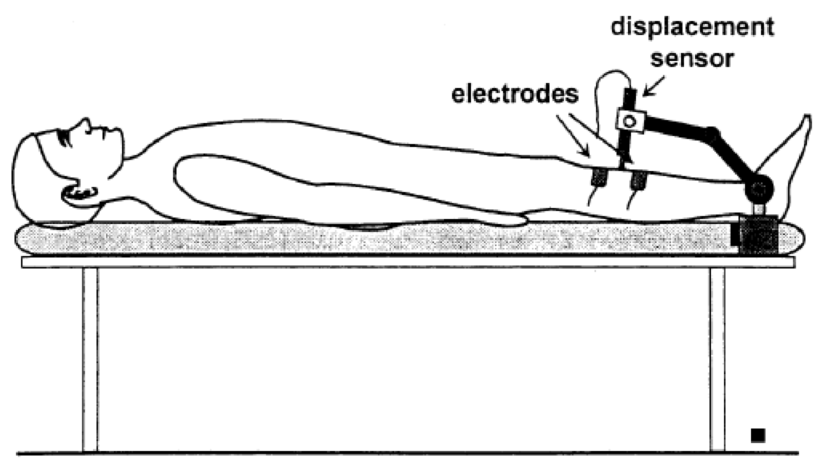
Quadriceps

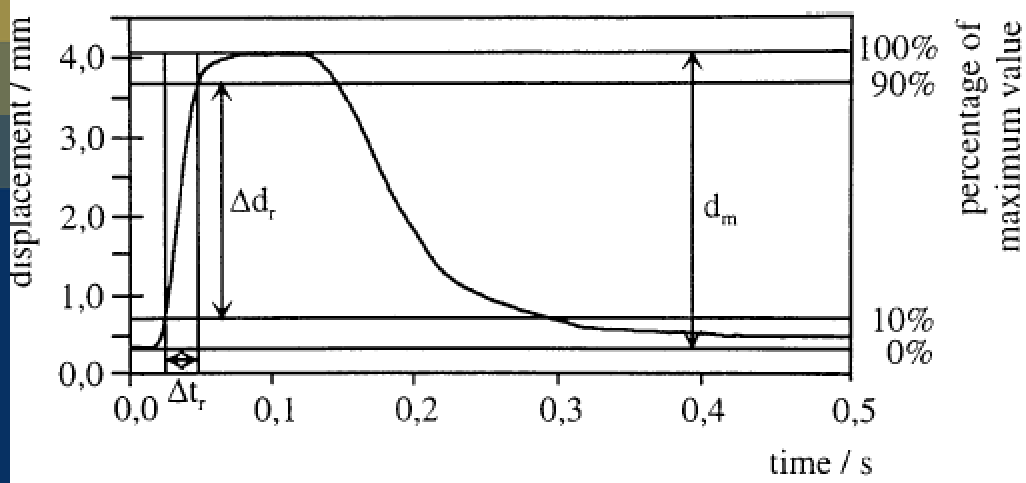
Brachioradialis

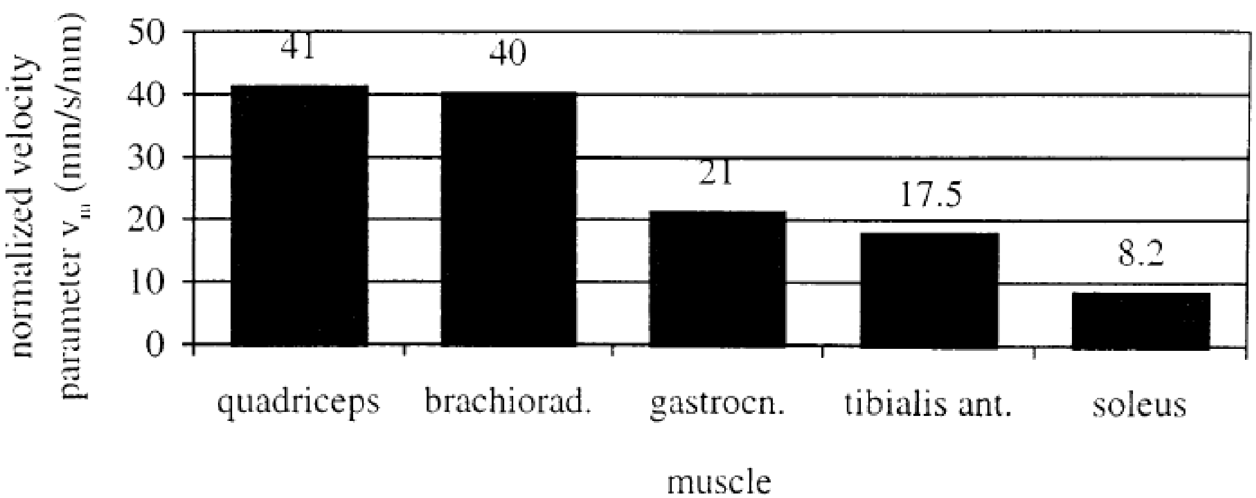
Soleus

Gastrocnemius

Tibialis Anterior




displacement / mm
4,0
3,0
2,0
1,0
0,0
0,0
0,1
0,2
0,3
0,4
0,5
time / s
Δt_r
Δd_r
d_m
100%
90%
10%
0%
percentage of maximum value


normalized velocity parameter v_m (mm/s/mm)
50
40
30
20
10
0
41
40
21
17.5
8.2
quadriceps
brachiorad.
gastrocn.
tibialis ant.
soleus
muscle

Med Bio Eng Comput (2006) 44:999-1006
DOI 10.1007/s11517-006-0114-5

ORIGINAL ARTICLE

Adaptive potential of human biceps femoris muscle demonstrated by histochemical, immunohistochemical and mechanomyographical methods

Raja Dahmane · Srdjan Djordjevič ·
Vika Smerdu

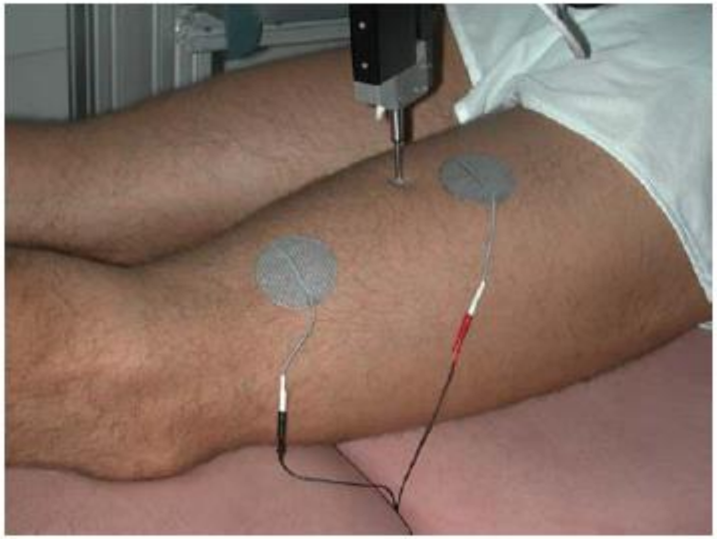
N = 15 (healthy males, age 17-40 yr)

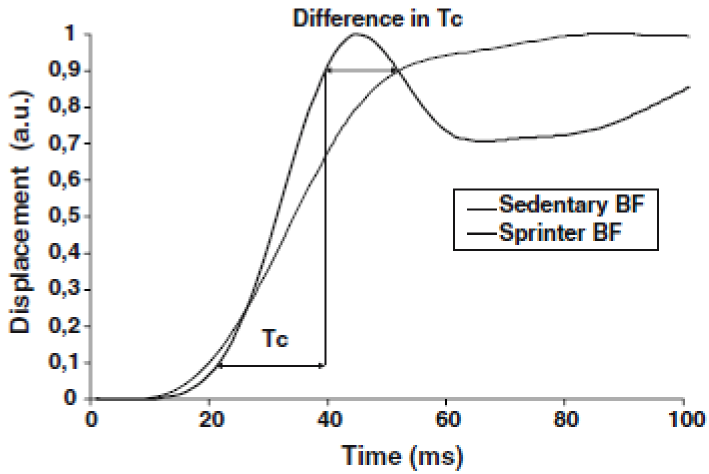
N = 15 (male sprinters, age 17-40 yr)
100m PB: 10.52

N = 15 (male cadavers, age 17-40 yr)

Muscle:

Biceps femoris + a number of other muscles

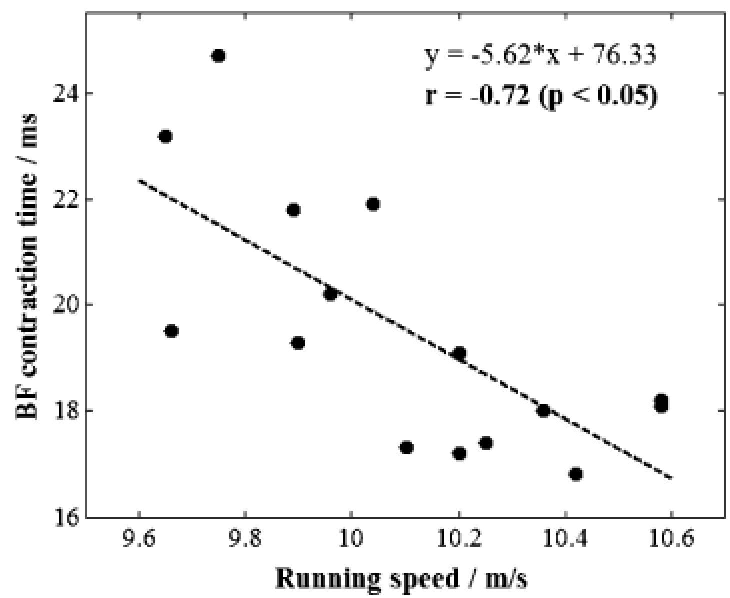




Tc

healthy males:
30.3 ms

sprinters:
19. 5 ms



Tc of healthy individuals vs. muscle composition of a matched sample of individuals who died suddenly

Muscle	Muscle 1	Fiber 2a	Type 2× (2b)	Contraction times/ms ± SD
Biceps brachii	46.4 ± 2.1	33.4 ± 2.2	16.6 ± 1.9	28.87 ± 4
Brachioradialis	47.1 ± 2.2	28.8 ± 2.5	19.5 ± 2.5	23.70 ± 5
Triceps brachii	38.0 ± 1.6	39.9 ± 2.0	17.9 ± 1.8	22.56 ± 6
Flexor digitorum superficialis	45.3 ± 1.9	41.8 ± 2.4	10.7 ± 1.7	25.40 ± 6
Extensor digitorum	47.5 ± 1.7	44.5 ± 1.8	6.5 ± 1.7	25.26 ± 5
Biceps femoris	49.0 ± 1.6	25.2 ± 1.3	20.7 ± 1.4	30.25 ± 3.5
Gastrocnemius	69.7 ± 2.0	24.1 ± 1.7	4.3 ± 0.7	44.75 ± 4
Soleus	90.6 ± 2.3	8.7 ± 2.0	0.3 ± 0.2	46.52 ± 4
Tibialis anterior	72.9 ± 2.2	20.5 ± 1.6	4.1 ± 1.2	32.83 ± 4.5

Med. Sci. Sports Exerc., Vol. 43, No. 9, pp. 1619–1625, 2011.

Noninvasive Estimation of Myosin Heavy Chain Composition in Human Skeletal Muscle

BOŠTJAN ŠIMUNIČ[1], HANS DEGENS[2], JÖRN RITTWEGER[2,3], MARCO NARICI[2], IGOR B. MEKJAVIĆ[4], and RADO PIŠOT[1]

[1]*Institute for Kinesiology Research, Science and Research Centre Koper, University of Primorska, Koper, SLOVENIA;* [2]*Institute for Biomedical Research into Human Movement and Health, Manchester Metropolitan University, Manchester, UNITED KINGDOM;* [3]*Institute of Aerospace Medicine, German Aerospace Center, Cologne, GERMANY;* and [4]*Department of Automation, Biocybernetics, and Robotics, Jožef Stefan Institute, Ljubljana, SLOVENIA*

N = 27 (age 20-83 yr)

Muscle:

Vastus lateralis, biopsy and TMG

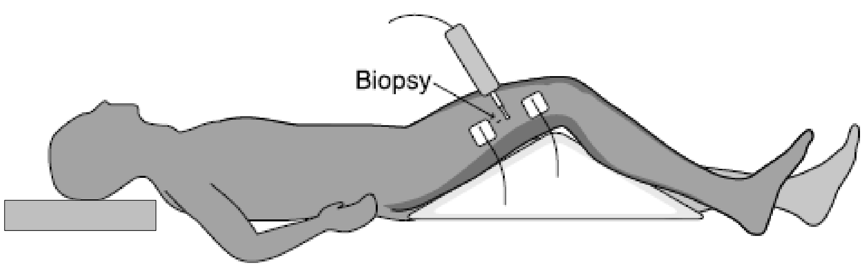
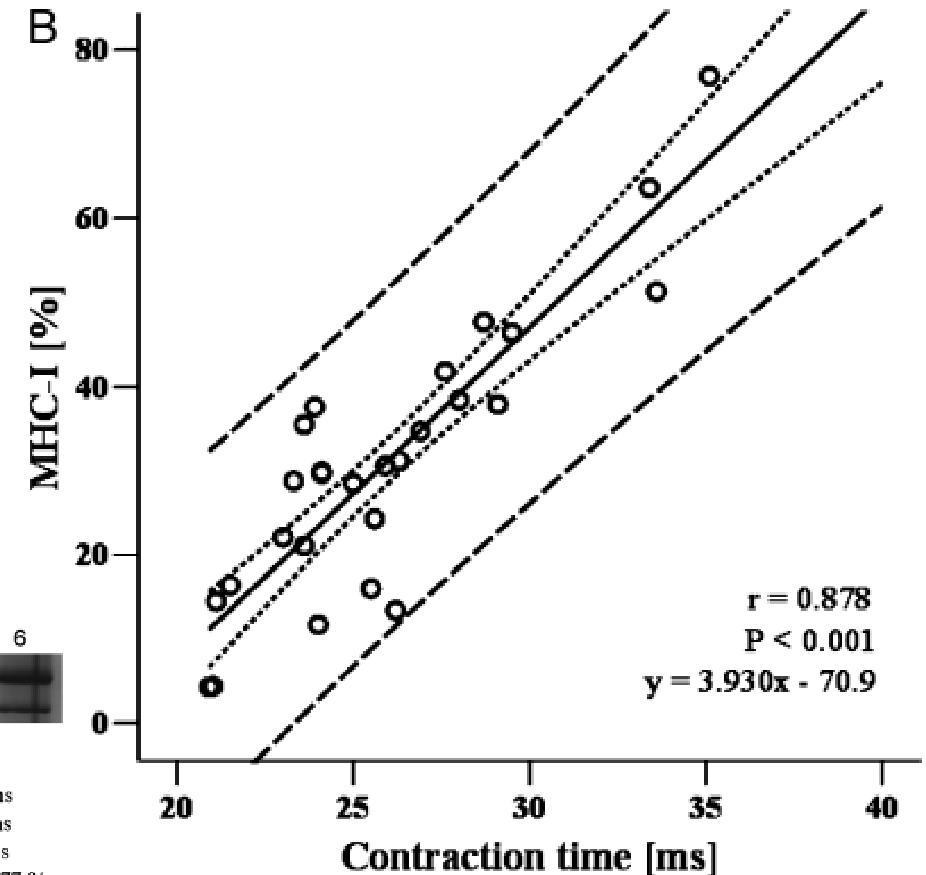
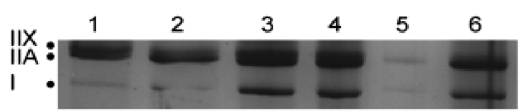
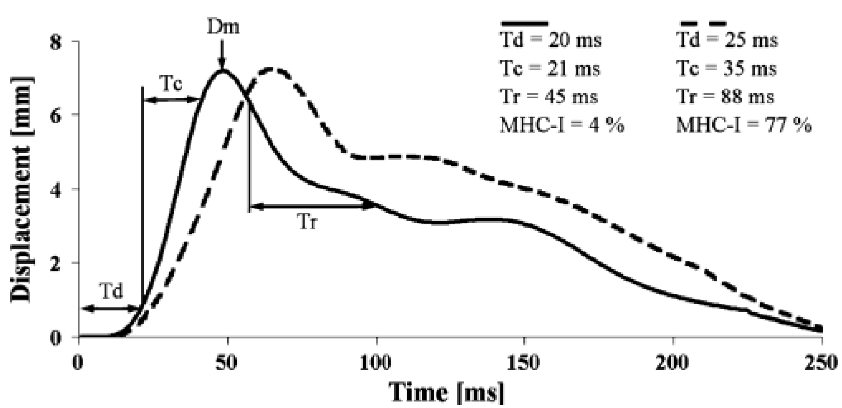


FIGURE 1—Schematic representation of the tensiomyographic measuring setup with marked biopsy spot at 40% (from the distal end) of the connecting line between the lateral knee cleft and the spina iliaca anterior superior.


B
MHC-I [%]
80
60
40
20
0
20
25
30
35
40
Contraction time [ms]
r = 0.878
P < 0.001
y = 3.930x - 70.9


1
2
3
4
5
6
IIX
IIA
I


Dm
Tc
Tr
Td
Displacement [mm]
Time [ms]
Td = 20 ms
Tc = 21 ms
Tr = 45 ms
MHC-I = 4 %
Td = 25 ms
Tc = 35 ms
Tr = 88 ms
MHC-I = 77 %

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Contents lists available at SciVerse ScienceDirect

Journal of Electromyography and Kinesiology

journal homepage: www.elsevier.com/locate/jelekin

Assessment of eccentric exercise-induced muscle damage of the elbow flexors by tensiomyography

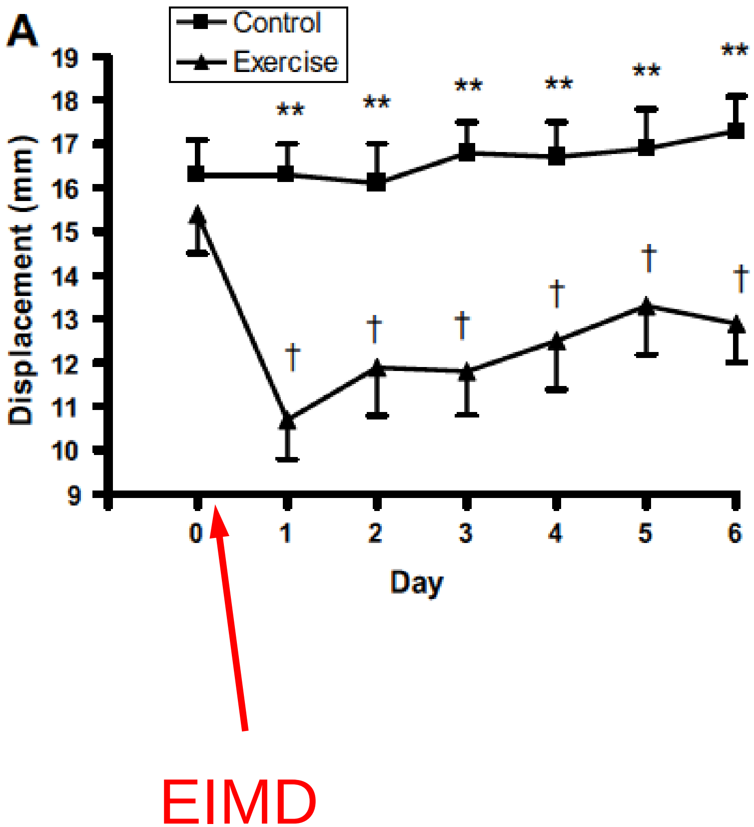
Angus M Hunter [a,*], Stuart DR Galloway [a], Iain J Smith [a], Jamie Tallent [b], Massimiliano Ditroilo [c], Malcolm M Fairweather [d], Glyn Howatson [b,e]

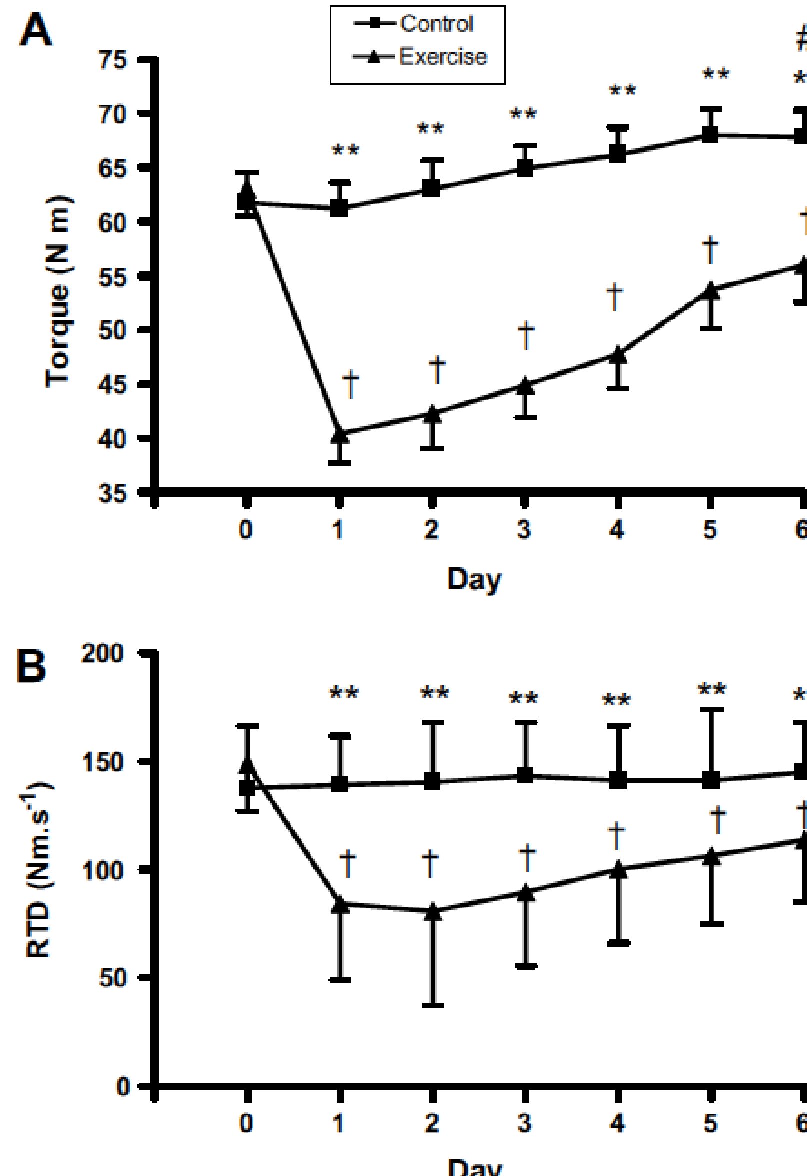
[a] Health and Exercise Sciences Research Group, University of Stirling, Stirling, UK
[b] Department of Sport and Exercise Sciences, Northumbria University, Newcastle, UK
[c] School of Public Health, Physiotherapy and Population Science, University College Dublin, Ireland
[d] Sportscotland Institute of Sport, Stirling, UK
[e] Centre of Aquatic Research, University of Johannesburg, Gaunteng, South Africa

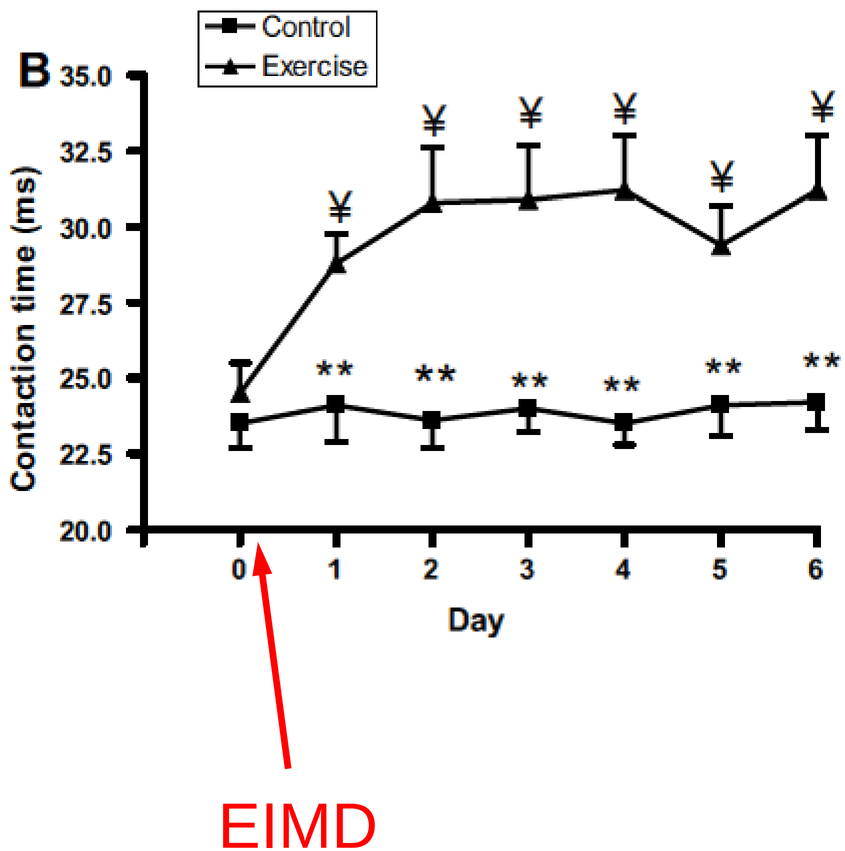
N = 19 (age 21.1±4.7 yr)

Muscle:

Biceps brachii


A
Control
Exercise
Displacement (mm)
19
18
17
16
15
14
13
12
11
10
9
0
1
2
3
4
5
6
Day
**
†
EIMD


A
Control
Exercise
Torque (N m)
75
70
65
60
55
50
45
40
35
0
1
2
3
4
5
6
Day
**
†
#
B
RTD (Nm.s-1)
200
150
100
50
0
0
1
2
3
4
5
6
Day


B
Control
Exercise
Contaction time (ms)
35.0
32.5
30.0
27.5
25.0
22.5
20.0
¥
**
0
1
2
3
4
5
6
Day
EIMD

Summary of the results from validity studies:

- **Tc** is directly correlated to % of type I muscle fibres and MHC-I

- **Tc** discriminates between sprinters and sedentary participants

- A fatigue-induced reduction in **Dm** is matched by a reduction in torque developed

- **Tc** and **Dm** are altered as a result of EIMD

Definition of reliability

- Intra-session reliability
- Inter-session reliability
- Long-term stability

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Journal of Electromyography and Kinesiology 18 (2008) 645–651
JOURNAL OF ELECTROMYOGRAPHY AND KINESIOLOGY
www.elsevier.com/locate/jelekin

Short-term repeatability of parameters extracted from radial displacement of muscle belly

Dejan Križaj *, Boštjan Šimunič, Tomaž Žagar

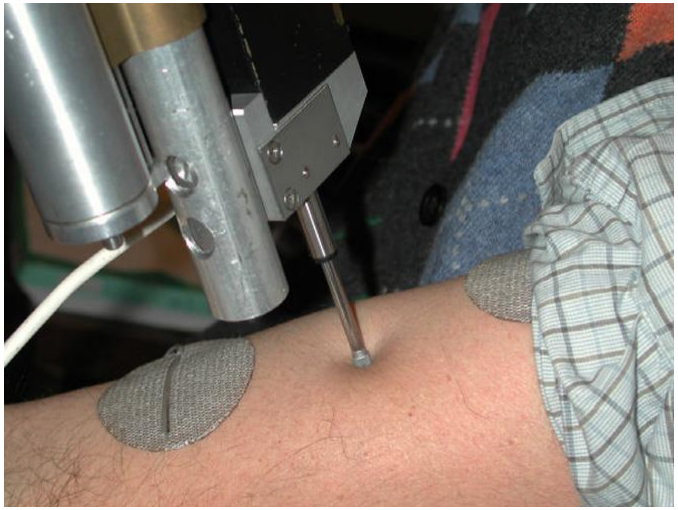
Faculty of Electrical Engineering, University of Ljubljana, Tržaška 25, 1000 Ljubljana, Slovenia

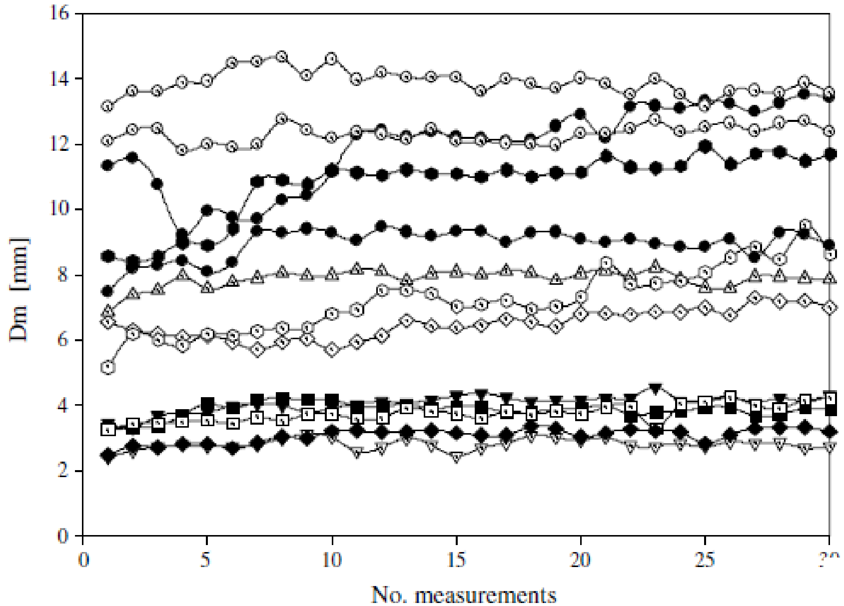
N = 13 (healthy participants, age 30.7)

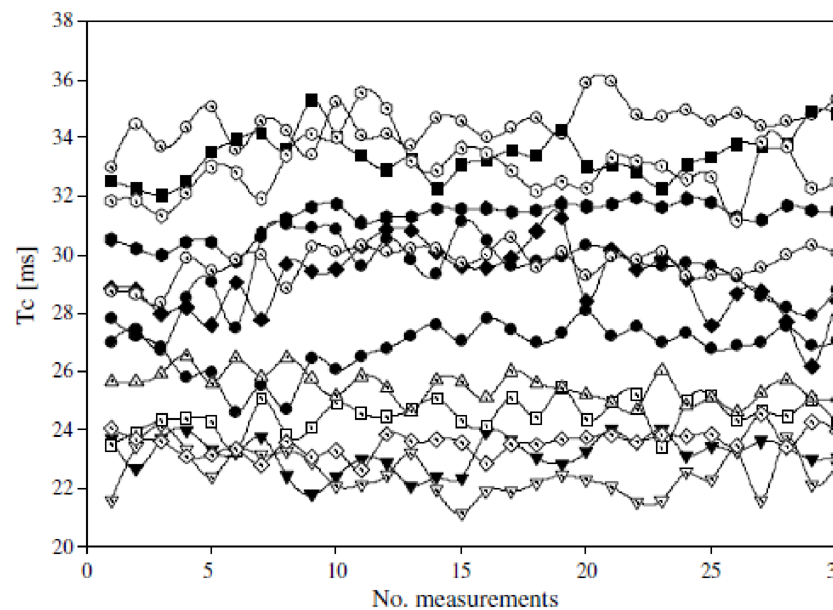
30 measurements, 10 s in between

Muscle:

Biceps brachii




Dm [mm]
No. measurements


Tc [ms]
No. measurements

	MIN	MAX	MEAN	NSEM	ICC
Dm	2.42	14.66	7.47	1.23	0.98
Td	22.53	35.61	28.08	0.43	0.94
Tc	21.14	35.92	28.18	0.48	0.97
Ts	44.65	256.06	136.81	1.30	0.89
Tr	17.18	162.01	81.39	1.92	0.86

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Between-day reliability of a method for non-invasive estimation of muscle composition

Boštjan Šimunič *

University of Primorska, Science and Research Centre Koper, Institute for Kinesiology Research, Slovenia

N = 10 (healthy participants, age 24.6)

Average of two measures taken over 3 consecutive days

Muscle:

Vastus lateralis

Vastus medialis

Biceps femoris

Table 1
Between-day reliability analysis for vastus medialis obliques (VMO, upper table), vastus lateralis (VL, middle table), and biceps femoris (BF, lower table).

	Test 1	Test 2	Test 3	$P_{F\text{-}Test}$	$\lvert Bias_{mean} \rvert$	RE	SEM	CV (%)	ICC [95% CI]
VMO									
Td (ms)	22.4 ± 1.7	22.4 ± 1.9	22.2 ± 1.6	0.606	0.19	±0.62	±0.42	2.8	0.94 [0.82–0.98]
Tc (ms)	25.7 ± 3.1	25.8 ± 3.1	25.8 ± 2.7	0.935	0.07	±0.56	±0.40	2.2	0.98 [0.95–0.99]
Ts (ms)	176.1 ± 22.3	185.5 ± 19.3	177.8 ± 23.1	0.065	6.29	±8.64	±5.46	4.9	0.94 [0.81–0.98]
Tr (ms)	42.7 ± 10.7	43.4 ± 11.2	41.1 ± 11.0	0.225	1.51	±2.60	±1.70	6.4	0.88 [0.78–0.96]
Dm (mm)	6.8 ± 1.3	6.5 ± 1.2	6.7 ± 1.3	0.791	0.23	±0.30	±0.17	4.7	0.98 [0.95–0.99]
VL									
Td (ms)	23.7 ± 0.9	23.9 ± 0.7	23.9 ± 1.2	0.645	0.12	±0.44	±0.30	1.8	0.89 [0.69–0.97]
Tc (ms)	22.6 ± 2.3	22.6 ± 2.1	23.1 ± 2.4	0.108	0.32	±0.41	±0.25	1.5	0.98 [0.94–0.99]
Ts (ms)	170.0 ± 27.2	169.7 ± 23.7	164.9 ± 20.5	0.445	3.22	±7.09	±4.99	4.4	0.96 [0.87–0.99]
Tr (ms)	64.9 ± 20.1	67.5 ± 18.1	70.3 ± 18.7	0.104	3.59	±4.63	±3.18	7.6	0.89 [0.82–0.96]
Dm (mm)	8.5 ± 2.4	8.4 ± 2.4	8.6 ± 2.4	0.791	0.23	±0.38	±0.25	4.7	0.99 [0.97–1.00]
BF									
Td (ms)	23.7 ± 3.0	23.6 ± 3.3	23.7 ± 3.5	0.928	0.07	±0.61	±0.40	2.6	0.98 [0.87–0.99]
Tc (ms)	29.1 ± 7.9	29.6 ± 8.5	30.6 ± 9.6	0.183	1.03	±1.50	±1.06	4.9	0.98 [0.95–1.00]
Ts (ms)	208.0 ± 19.8	205.8 ± 21.1	206.4 ± 25.2	0.830	1.48	±6.57	±5.01	3.3	0.95 [0.84–0.99]
Tr (ms)	56.2 ± 17.1	63.4 ± 27.1	62.7 ± 19.2	0.063	4.81	±6.19	±4.12	9.3	0.89 [0.80–0.95]
Dm (mm)	5.5 ± 2.1	5.6 ± 2.1	5.7 ± 2.4	0.262	0.13	±0.23	±0.43	4.2	0.99 [0.98–1.00]

Td – delay time; Tc – contraction time; Ts – sustain time; Tr – half relaxation time; Dm – maximal displacement; $P_{F\text{-}Test}$ – RM ANOVA significance; $\lvert BIAS_{mean} \rvert$ – average of absolute bias; RE – random error; SEM – standard error of measurement; CV – coefficient of variation; ICC – intra-class correlation coefficient; CI – confidential interval.

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Long-term stability of tensiomyography measured under different muscle conditions

Massimiliano Ditroilo[c,*], Iain J. Smith[a], Malcolm M. Fairweather[b], Angus M. Hunter[a]

[a] Health and Exercise Sciences Research Group, University of Stirling, Scotland, United Kingdom
[b] Sportscotland Institute of Sport, Stirling, Scotland, United Kingdom
[c] Department of Sport, Health & Exercise Science, Faculty of Science, University of Hull, England, United Kingdom

N = 21 (healthy participants, age 21.3)

Muscle:

Gastrocnemius medialis

Research design:

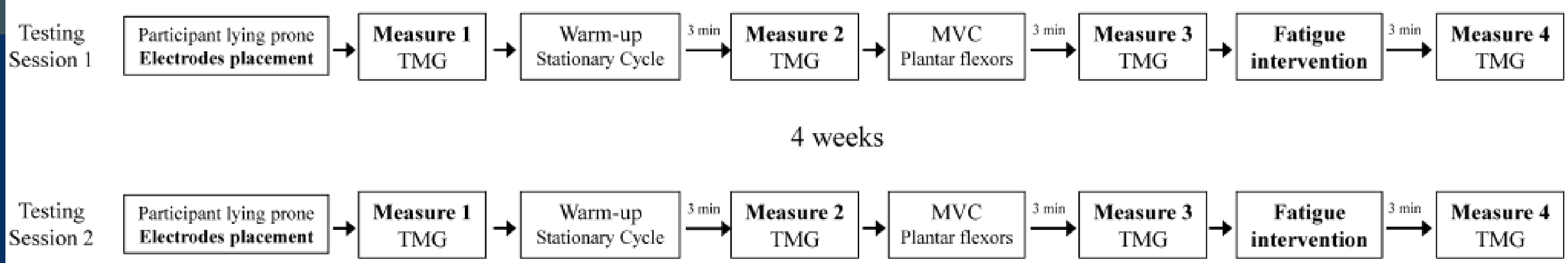
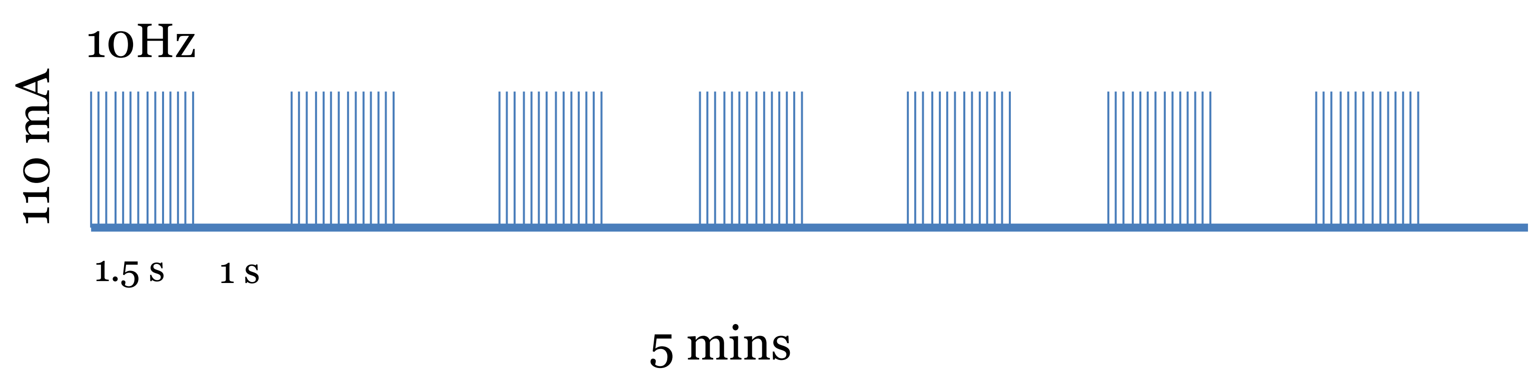


Fig. 1. Overview of the testing protocol. TMG = tensiomyography; MVC = maximal isometric voluntary contraction;

Fatigue protocol:



	CV (95% CI)			
	M1	M2	M3	M4
Tc	9.4 (6.3–12.5)	9.1 (6.4–11.8)	8.1 (5.4–10.8)	3.8 (2.3–5.3)
Ts	6.8 (3.7–9.9)	8.2 (5.0–11.3)	5.5 (3.7–7.3)	5.3 (3.1–7.6)
Tr	30.3 (18.2–42.4)	32.7 (18.4–47.0)	27.8 (14.5–41.1)	29.4 (19.2–39.6)
Td	9.2 (5.2–12.9)	8.2 (4.2–12.3)	7.8 (3.7–11.9)	7.0 (3.2–10.8)
Dm	14.8 (10.4–19.3)	11.1 (7.0–15.1)	10.1 (5.0–15.2)	8.0 (5.0–11.0)

Summary of the results from reliability studies:

- **Dm** and **Tc** appear to have the highest
  - -Intra-session (ICC 0.98 and 0.97),
  - -Inter-session (ICC 0.98 to 0.99; CV 1.5 to 4.9%)
  - -Long term stability (ICC 0.62 to 0.95; CV 3.8 to 14.8%)

- **Tr** is consistently the least reliable parameter across studies