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Effects of Whole-Body Vibrations on Neuromuscular Fatigue

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We use this protocol and it's working

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Keywords: Level of voluntary activation, Maximum voluntary contraction, Whole bodt vibration, Double interpolated twitch technique, Doublets, high to low frequency ratio, neuromuscular fatigue, single twitch, double twitch, electrical stimulation, body vibrations on neuromuscular fatigue purpose, magnitude of neuromuscular fatigue, neuromuscular fatigue, neuromuscular fatigue purpose, static squatting, body vibration, total exercise exposure, single twitch peak torque, frequency fatigue ratio, vibration, maximum voluntary contraction, level of voluntary activation

Abstract

Purpose: The aim of the study was to investigate the origin and magnitude of neuromuscular fatigue induced by half-squat whole-body vibration.
Methods: Ten young, recreationally trained adults participated in six fatiguing protocols, each consisting of several sets of 30, 60 or 180 s static squatting superimposed with vibration (WBV_{30}, WBV_{60}, WBV_{180}) or without vibration ($SHAM_{30}$, $SHAM_{60}$, $SHAM_{180}$) for a total exercise exposure of 9-minutes in each trial. Maximum voluntary contraction (MVC), level of voluntary activation (%VA), single twitch peak torque (TW_{PT}), low- (T_{20}) and high-frequency (T_{100}) doublets, and low-to-high-frequency fatigue ratio ($T_{20/100}$) were assessed before, immediately after, 15 and 30 minutes after each fatiguing protocol.

Guidelines

Study design:

each subject performed three different fatiguing exercises interventions with WBV and three exercise interventions in a SHAM condition without WBW (SHAM) to discriminate the effect of WBV. Each intervention contained a cumulative exercise period with a duration of 9 minutes divided into different sets (either 18 × 30 s or 9 × 60 s or 3 × 180 s), with 120 s rest between sets. Each intervention was randomly executed on different visits at the same day-time with at least 7 days rest in-between.

Materials

Equipment	
DS7A	NAME
HV Constant Current Stimulator	TYPE
Digitimer	BRAND
1	SKU

Equipment	
10 mm Ag–AgCl electrode	NAME
Type 0601000402	TYPE
Controle Graphique Medical	BRAND
1	SKU
https://controle-graphique.fr/	LINK
Cathode	SPECIFICATIONS

Equipment	
ELECTRODES PERFORMANCE 50 X 100MM PIN	NAME
Electrode	TYPE
Compex	BRAND
1	SKU

Equipment	
Isometric machine with a force transducer	NAME
Isometric dynamometer	TYPE
Custom Made	BRAND
1	SKU
Force transducer (MES, Maribor, Slovenia)	SPECIFICATIONS

Equipment

Galileo Fit	NAME
Whole body vibration platform - WBV	TYPE
Novotec Medical GmbH	BRAND
1	SKU

Troubleshooting

Equipment calibration

1 We calibrated the

Equipment	
Isometric machine with a force transducer	NAME
Isometric dynamometer	TYPE
Custom Made	BRAND
1	SKU
Force transducer (MES, Maribor, Slovenia)	SPECIFICATIONS

prior to each measuring session.
The signal of the dynamometer was connected to

Equipment	
PowerLab 16/35 (PL3516)	NAME
DAQ - data acquisition hardware	TYPE
ADInstruments	BRAND
1	SKU

PDF

running

Software	
LabChart	NAME
Windows XP	OS
ADInstruments Australia	DEVELOPER

The same machine has been used in several other studies

Citation

Tomazin K, Dolenec A, Strojnik V (2008)
. High-frequency fatigue after alpine slalom skiing..
European journal of applied physiology.

https://doi.org/10.1007/s00421-008-0685-y LINK

Citation

García-Ramos A, Tomazin K, Feriche B, Strojnik V, de la Fuente B, Argüelles-Cienfuegos J, Strumbelj B, Štirn I
(2016)
. The Relationship Between the Lower-Body Muscular Profile and Swimming Start Performance..
Journal of human kinetics.

https://doi.org/10.1515/hukin-2015-0152 LINK

We calibrated the force transducer, by hanging a 20 kg weight. We read the Voltage transformation to calculate the exerted torque.

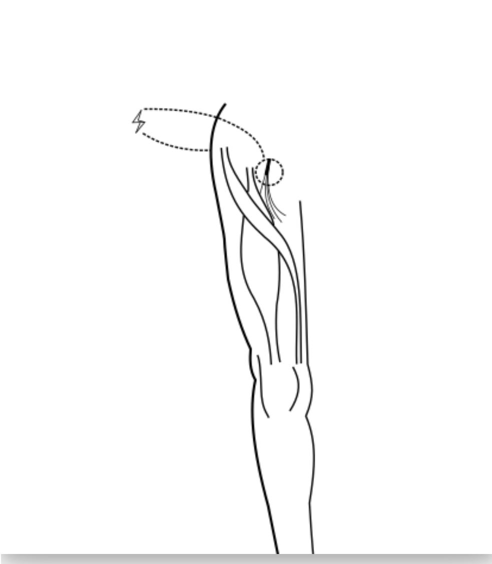
Pre experiment procedures

2

We invited the subject to seat on the Isometric dynamometer in order to adjust the seating position and lever arm. The subject was positioned in an upright sitting position, the trunk at 100° leaning against the backrest of the isometric dynamometer, fixed by straps over the pelvis and a horizontal pad over the distal third of the thigh. The knee joint axis was aligned with the mechanical axis of the dynamometer. The shin pad was placed just above to the medial malleolus. The right knee joint was fixed at a 60° angle (0° = full extension)

3 Femoral nerve stimulation electrode placement

We invited the participants to flex their hip from in a seated position, while we palpated the iliac fossa



Schematic view of the leg and the stimulation electrode placement

and placed the electrode (cathode) into the femoral triangle.

Equipment	
10 mm Ag–AgCl electrode	NAME
Type 0601000402	TYPE
Controle Graphique Medical	BRAND
1	SKU
https://controle-graphique.fr/	LINK
Cathode	SPECIFICATIONS

A larger self-adhesive electrode placed over the gluteal fold served as an anode.

Equipment	
ELECTRODES PERFORMANCE 50 X 100MM PIN	NAME
Electrode	TYPE
Compex	BRAND
1	SKU

4 Femoral nerve test stimulation

Electrical impulses (single, square wave, 1-ms duration) elicited by a high voltage constant current electrical stimulator

Equipment

DS7A	NAME
HV Constant Current Stimulator	TYPE
Digitimer	BRAND
1	SKU

were used to trigger the muscle response, which was detected as a change in knee extensors torque.

4.1 We elicited several impulses (3 in average, max 6) at a fixed intensity of 20 mA at a frequency of 0.1 Hz and slightly moving the cathode in order to find the spot which produced the highest response (highest torque).

Warm-up

5 00:06:00 warm-up routine consisting of bench stepping (20 cm high) at a frequency of 0.5 Hz , with a leg exchange each minute

6 00:02:00 rest

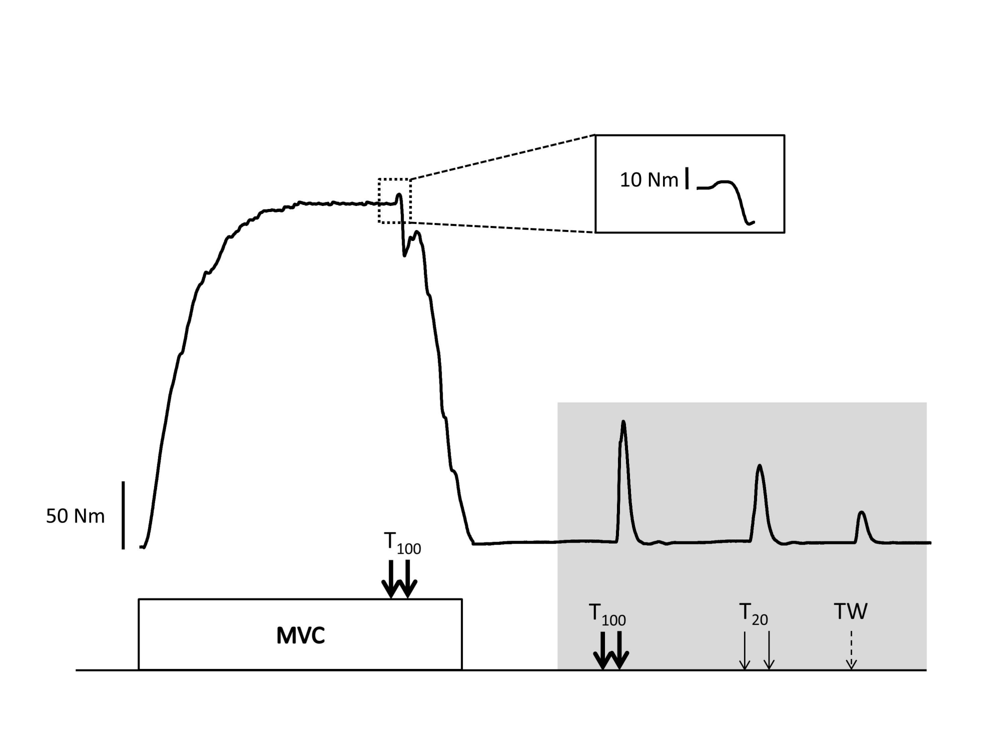
Pre experiment procedure

7 The stimulation intensity to elicit the maximum knee extensor isometric twitch was determined in each subject after Warm-up (starting from 10 mA) progressively increasing the stimulation intensity by 10 mA until no further increase in torque was observed despite further increment in current. The current at maximal twitch torque was

additionally increased by a factor of 1.5 to obtain a supra-maximal stimulus. This intensity was maintained for the entire visit.

PRE - assessment (t_0)

8



Schematic representation of the assessment timeline and the change in knee extensors torque

8.1 ***Maximal voluntary contraction with double twitch interpolated techniques***

Subjects were asked to perform a 5 s maximal isometric voluntary **(MVC)** knee extension

Citation

Verges S, Maffiuletti NA, Kerherve H, Decorte N, Wuyam B, Millet GY (2009)
. Comparison of electrical and magnetic stimulations to assess quadriceps muscle function..
Journal of applied physiology (Bethesda, Md. : 1985).

https://doi.org/10.1152/japplphysiol.01051.2007 LINK

The signal was smoothed using a 0.5 s window moving average filter and peak torque **(MVC)** was retained for analysis. The double twitch interpolated technique

Citation

Allen DG, Lännergren J, Westerblad H (1995)
. Muscle cell function during prolonged activity: cellular mechanisms of fatigue..
Experimental physiology.

was performed by superimposing a 100 Hz doublet on the isometric plateau **(T_{MVC})**. A second analogous stimulation 100 Hz **(T_{100})** on the relaxed muscle followed after 3 s.

The ratio of the amplitude of the T_{MVC} over T_{100} was then calculated to obtain the level of voluntary activation **(%VA)**:

$$\%VA = (1 - \frac{T_{MVC} - MVC}{T_{100}}) * 100$$

8.2 ***High- and low-frequency doublets***

The torque change induced by the paired high- (100 Hz , i.e. 10 ms interstimulus interval) and low-frequency (20 Hz , i.e. 50 ms interstimulus interval) supramaximal electrical stimuli were analyzed.

Citation

Place N, Maffiuletti NA, Martin A, Lepers R (2007)
. Assessment of the reliability of central and peripheral fatigue after sustained maximal voluntary contraction of the quadriceps muscle..
Muscle & nerve.

Citation

Verges S, Maffiuletti NA, Kerherve H, Decorte N, Wuyam B, Millet GY (2009)
. Comparison of electrical and magnetic stimulations to assess quadriceps muscle function..
Journal of applied physiology (Bethesda, Md. : 1985).

https://doi.org/10.1152/japplphysiol.01051.2007 LINK

The following parameters were obtained: peak torque from 100 Hz doublet (**T_{100}**), peak torque from 20 Hz doublet (**T_{20}**) and the low- to thehigh-frequency ratio (**$T_{20/100}$**) was calculated using the following formula:

$$T_{20/100} = \frac{T_{20}}{T_{100}} * 100$$

This ratio was then used as a surrogate of low- to high-frequency tetanic stimulation.

Citation

Verges S, Maffiuletti NA, Kerherve H, Decorte N, Wuyam B, Millet GY (2009)
. Comparison of electrical and magnetic stimulations to assess quadriceps muscle function..
Journal of applied physiology (Bethesda, Md. : 1985).

https://doi.org/10.1152/japplphysiol.01051.2007 LINK

8.3 ***Single twitch***

The torque change induced by the single supramaximal femoral nerve stimuli was analysed.

Citation

Place N, Maffiuletti NA, Martin A, Lepers R (2007)
. Assessment of the reliability of central and peripheral fatigue after sustained maximal voluntary contraction of the quadriceps muscle..
Muscle & nerve.

The following parameters were obtained: 1) the maximum torque value (**TW_{PT}**);

Intervention

9 Intervention

The interventions were performed on

Equipment

Galileo Fit	NAME
Whole body vibration platform - WBV	TYPE
Novotec Medical GmbH	BRAND
1	SKU

which was switched on (or off for SHAM conditions) at a frequency of 26 Hz . Subjects were instructed to maintain a half-squat position with their knees flexed at an angle of 60°. Subjects stood with their feet 40 cm apart where the tilting platform reaches peak-to-peak displacement amplitude of 5 mm.

Citation

Ritzmann R, Gollhofer A, Kramer A (2013)
. The influence of vibration type, frequency, body position and additional load on the neuromuscular activity during whole body vibration..
European journal of applied physiology.

https://doi.org/10.1007/s00421-012-2402-0 LINK

POST assessments - (t_f) 15m

10 Repete assessment procedure 15m

go to step #8

POST 15 assessments - (t_{f15}) 15m

11 Repete assessment procedure 15m

POST 30 assessments - (t_{f30}) 15m

12 Repete assessment procedure go to step #8 15m

Data analysis

13

A two-way factorial ANOVA was conducted in

Software	
R programming language	NAME
The R Foundation	DEVELOPER
Comprehensive R Archive Network	SOURCE LINK

with the

Software	
afex: Analysis of Factorial Experiments	NAME
Henrik Singmann	DEVELOPER
https://cran.r-project.org/web/packages/afex/index.html	SOURCE LINK

to compare the main effects of *time* and *trial* and the interaction effect of *time x trial.* Generalized eta squared (η^2) effect sizes were calculated for the ANOVA main and interaction effects.

Software

emmeans: Estimated Marginal Means, aka Least-Squares Means NAME

Russell Lenth [aut, cre, cph], Henrik Singmann [ctb], Jonathon Love [ctb], Paul Buerkner [ctb], Maxime Herve [ctb] DEVELOPER

cran.r-project.org SOURCE LINK

The *emmeans* package (Lenth et al. 2018) was used to perform follow-up post hoc analysis. Planned comparisons were performed using Sidak corrected linear contrasts comparing. Statistical significance was set at $p < 0.05$. Standardized changes in the mean of each measure were used to assess magnitudes of effects and were calculated using Cohen's d and interpreted using thresholds of 0.2, 0.5, 0.8 for small, moderate and large, respectively (Batterham and Hopkins 2006). An effect size of ± 0.2 was considered the smallest worthwhile effect with an effect size of < 0.2 considered to be trivial. The effect was considered unclear if its 95% confidence interval overlapped the thresholds for small positive and small negative effects.

Citations

Step 1

García-Ramos A, Tomazin K, Feriche B, Strojnik V, de la Fuente B, Argüelles-Cienfuegos J, Strumbelj B, Štirn I. The Relationship Between the Lower-Body Muscular Profile and Swimming Start Performance.
https://doi.org/10.1515/hukin-2015-0152

Step 1

Tomazin K, Dolenec A, Strojnik V. High-frequency fatigue after alpine slalom skiing.
https://doi.org/10.1007/s00421-008-0685-y

Step 8.1

Verges S, Maffiuletti NA, Kerherve H, Decorte N, Wuyam B, Millet GY. Comparison of electrical and magnetic stimulations to assess quadriceps muscle function.
https://doi.org/10.1152/japplphysiol.01051.2007

Step 8.1

Allen DG, Lännergren J, Westerblad H. Muscle cell function during prolonged activity: cellular mechanisms of fatigue.

Step 8.2

Verges S, Maffiuletti NA, Kerherve H, Decorte N, Wuyam B, Millet GY. Comparison of electrical and magnetic stimulations to assess quadriceps muscle function.
https://doi.org/10.1152/japplphysiol.01051.2007

Step 8.2

Place N, Maffiuletti NA, Martin A, Lepers R. Assessment of the reliability of central and peripheral fatigue after sustained maximal voluntary contraction of the quadriceps muscle.

Step 8.2

Verges S, Maffiuletti NA, Kerherve H, Decorte N, Wuyam B, Millet GY. Comparison of electrical and magnetic stimulations to assess quadriceps muscle function.
https://doi.org/10.1152/japplphysiol.01051.2007

Step 8.3

Place N, Maffiuletti NA, Martin A, Lepers R. Assessment of the reliability of central and peripheral fatigue after sustained maximal voluntary contraction of the quadriceps muscle.

Step 9

Ritzmann R, Gollhofer A, Kramer A. The influence of vibration type, frequency, body position and additional load on the neuromuscular activity during whole body vibration.
https://doi.org/10.1007/s00421-012-2402-0