The Effect of Vibration Exercise on Aspects of Muscle Physiology and Muscular Performance

Darryl J. Cochrane (MPhEd)

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Massey University
Palmerston North
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Abstract

It has been proposed that the increases in muscle force and power following acute vibration exercise are similar to that of several weeks of conventional resistance or explosive power training. Further, it has been purported that vibration exercise operates via a stretch-reflex response which elicits a small change in muscle length. However, despite its wide use there remain gaps of knowledge on aspects such as physiological effects, mechanism of action, clinical effects, and even details of regimens for particular therapeutic use. Therefore, the aim of this thesis was to investigate the acute effects of vibration exercise on muscle performance and to examine the physiological aspects of its use in the young and older people, and competitive athletes. This thesis reported that acute upper-body vibration enhanced concentric peak power, but it was not significantly greater than concentric (arm-cranking) exercise. When matched for metabolic rate, vibration exercise elevated muscle temperature more quickly than traditional forms of warm-up by cycling or passive heating, but there were no significant differences in the increase in muscle power between the interventions, which suggested that the interventions were temperature dependent. There was no apparent benefit in performing a shallow, fast tempo dynamic squat with vibration because muscle temperature, cardiovascular indices, and metabolic rate were increased by the same amount and rate without vibration. Further, the Jendrassik manoeuvre did not potentiate the metabolic rate in young or older adults when superimposed with vibration exercise and the patellar reflex was not enhanced after vibration exercise, but muscle twitch potentiation was evident. However, low frequency vibration exercise induced a small change in muscle length and increased muscle activation, suggesting that spinal reflexes were involved. In conclusion, vibration exercise with a static squat could be used as a warm-up modality after interval breaks, as it would incur a low metabolic cost and be time efficient. It appears that the increases in muscle performance from vibration exercise are not caused by a neurogenic potentiation because patellar tendon reflex showed no significant augmentation and muscle twitch properties were enhanced. Vibration exercise elicited a small increase in metabolic rate and cardiovascular indices. Given that a main objective of a balanced exercise programme is to increase aerobic capcity it would be unwise to completely substitute conventional aerobic exercise with vibration. However, when conventional aerobic exercise is not possible, for example, in aged, cardiovascular compromised persons, vibration exercise could be implemented at an early stage because it could provide a safe induction of a low level of cardiovascular strain. Vibration exercise has the potential to benefit sport, exercise, and health however, it should be used to compliment other modalities but it should never be used in preference or in isolation to other programmes.

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List of Publications and Presentations

Chapters 2 to7 have been submitted to international peer-reviewed journals. The details of these publications are as follows

Peer Reviewed Journals

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Cochrane D.J., Stannard S.R., Firth E.C., Rittweger, J. (2010). The comparison of muscle temperatures during static and dynamic squatting with and without acute vibration exercise. *Clinical Physiology and Functional Imaging* (*In Press*).

Cochrane D.J., Sartor F., Winwood K., Stannard S.R., Narici M., Rittweger J. (2008). A comparison of the acute physiological effects of acute whole-body vibration exercise in young and older people. *Archives of Physical Medicine & Rehabilitation* 89:815-821.

Cochrane D.J., Stannard S.R., Loram I., Rittweger J. (2009). Changes in joint angle, muscle-tendon complex length, muscle contractile tissue displacement and modulation of EMG activity during acute whole-body vibration. *Muscle Nerve* 40:420-429.

Cochrane D.J., Stannard S.R., Firth E.C., Rittweger, J. (2010). Acute whole-body vibration elicits post-activation potentiation. *European Journal of Applied Physiology* 108:311-319.

Conference Papers

Cochrane D.J., Stannard S.R., Sargeant TJ., Rittweger J. (2008). The rate of muscle temperature increase during acute vibration exercise. Australian Association for Exercise and Sports Science, 27-30 March 2008, Melbourne, Australia.

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Conference Posters

Cochrane D.J., Stannard S.R., Walmsley A., Firth E.C. (2008). The acute effect of vibration exercise on concentric muscular characteristics. Australian Association for Exercise and Sports Science 27-30 March, Melbourne, Australia.

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List of Abbreviations

A

a	Acceleration
A	Amplitude (peak-to-peak)
AC	Arm cranking
AVI	Audio video interleave

B

BM	Body mass
BB	Barbell
BP	Blood pressure
DB	Dumbbell

C

Ca^{2+}	Calcium
CD	Contractile length
CMJ	Countermovement jump
CMJ-PP	Countermovement jump peak power
CMJ-Ht	Countermovement jump maximum height
CMV	Calf muscle volume
CYCL	Stationary cycling

D

DS+	Dynamic squatting with vibration exercise
DS–	Dynamic squatting without vibration exercise
DS	Dynamic squatting

E

EMD	Electromechanical delay
EMG	Electromyography
EMG_{rms}	Electromyography root-mean-square

F

f	Frequency

G

g	Gravitational acceleration

H

Hz	Hertz

J

JH	Jump height
JVC	Jendrassik maximum voluntary contraction

M

Mean T_{sk}	Mean skin temperature
MG	Medial gastrocnemius
MIC	Five second maximal isokinetic cycle test
MIC-PP	Maximal isokinetic cycle peak power
MTC	Muscle tendon complex
MVC	Maximal voluntary contraction

P

PAP	Post-activation potentiation
PAQ	Physical activity questionnaire
PBP	Prone bench pull
PEH	Peri-event histograms
PF	Muscle twitch peak force
PJP	Peak jump power
PP	Peak power

R

RFD	Rate of force development
RH	Relative humidity
RL	Patellar reflex latency
RP	Reflex potentiation
RPE	Ratings of perceived exertion
RM	Repetition maximum

S

SOL	Soleus
SS+	Static squatting with vibration
SS–	Static squatting without vibration
SS	Static squatting
SV	Side-alternating vibration

T

ΔT_m	Change in muscle temperature
T_{amb}	Ambient temperature
T_c	Core temperature
$\dot{T}_m$	Rate of muscle temperature change
T_{sk}	Skin temperature
TA	Tibialis anterior
TLS	Thermal leg sensation
TMS	Transcranial magnetic stimulation
TMV	Thigh muscle volume
TP	Twitch potentiation
TPF	Time to peak force
TVR	Tonic vibration reflex

V

VBX+	With vibration exercise
VBX−	Without vibration exercise
VBX	Vibration exercise
VJ	Vertical jump
VL	Vastus lateralis
$\dot{V}O_2$	Rate of oxygen uptake
VV	Vertical synchronous vibration

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