



OPTIMIZATION OF NEUROMUSCULAR ACTIVATION IN WHOLE BODY VIBRATION – EFFECT OF TYPE, FREQUENCY, AMPLITUDE AND BODY POSITION.

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SUMMARY

Although there is substantial amount of scientific papers dealing with whole body vibration (WBV), only few investigate optimal neuronal activation as a function of frequency, amplitude or body position. The present study aims to determine the influence of WBV parameters on the neuronal activation in order to identify those conditions that cause a high neuromuscular activation and therefore provide optimal training conditions. In a randomized cross-over study, the EMG activity of six leg muscles was analyzed in 18 subjects with respect to the following determinants: (1) vibration type (rotational (RV) vs. synchronous vibration (SV)), (2) frequency (5–10–15–20–25–30 Hz), (3) amplitude (2 vs. 4mm), (4) knee flexion angle (10°–30°–60°) and stance condition (forefoot vs. normal stance). The results are: (1) EMG activity in RV was enhanced compared to SV ($P<0.05$); enhanced (2) frequency or (3) amplitude caused a progressive increase in EMG activity ($P<0.05$). (4) The EMG activity was highest for the knee extensors when the knee joint was 60° flexed ($P<0.05$) and for the plantar flexors in the forefoot stance condition ($P<0.05$). In conclusion, the combination of high vibration frequencies and amplitudes on a RV platform led to highest EMG activities and hence, is supposed to provide a favourable parameter setting for WBV training. With respect to body posture, a knee flexion of 60° and forefoot stance appear to be beneficial for the knee extensors and the plantar flexors, respectively.

INTRODUCTION

Whole body vibration (WBV) is widely applied in different areas of the rehabilitative medicine, geriatrics and as a training method for elite athletes [1]. Thus, the respective research has increased during the last decade [2]. However, in spite of the considerable number of vibration-related manuscripts, just a few target fundamental questions such as optimal frequency, amplitude or body position on the training device [3-5].

Detailed knowledge of the influence of the training setup and the selected WBV parameters is required when designing a WBV-based training regimen with the objective to achieve a distinct type of adaptation in a target muscle group. From literature it is well known that the muscles' EMG activity is related to the extent of the muscle fibers' recruitment and frequency [6]. Based on this relation, The

EMG activity could be used to easily determine the activation intensity of the muscle and thus, might be an appropriate predictor for the muscle's workload in a given set of WBV treatment.

This work presents a methodological approach in order to identify those conditions that provide a high neuromuscular activity and therefore a high workload during WBV training. The purpose of the present study was to estimate an optimized WBV training setting based on the level of the muscles' activation intensities.

METHODS

The electromyographic (EMG) activity of the soleus (Sol), gastrocnemius medialis (GM), tibialis anterior (TA), rectus femoris (RF), vastus medialis (VM) and biceps femoris (BF) muscles were measured in 18 healthy subjects during WBV. In a cross-over study design (Figure 1), the independent variables have been varied as follows: (1) vibration type (rotational (RV) and synchronous vibration (SV)), (2) frequency (5-30Hz in steps of 5Hz), (3) amplitude (2 and 4mm) and (4) body position (knee angles of 10, 30 and 60°; two different foot positions: forefoot vs. normal stance, i.e. heel and forefoot in contact with the vibration platform). The statistical analysis consisted of an ANOVA.

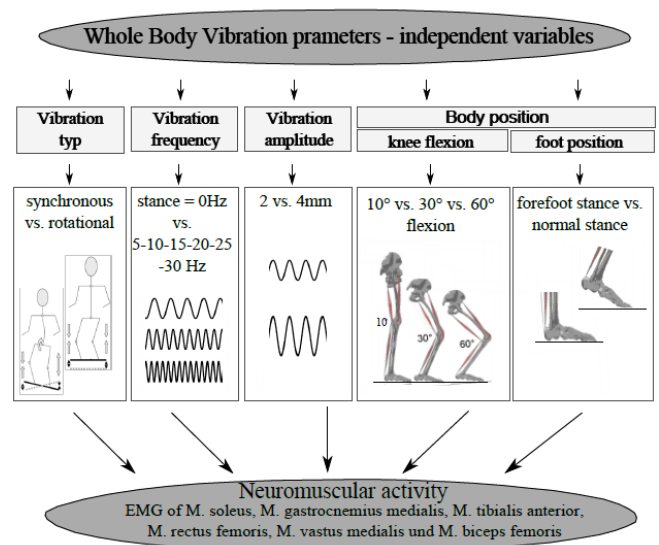


Figure 1: Schematics of the study design.

Table 1: Differences in EMG activity during WBV in response to two different vibration types and amplitudes.

Muscles	SOL	GM	TA	RF	VM	BF
2 vs. 4mm - amplitude differences [%]	+40±11%*	+33±14%*	+42±16%*	+38±9%*	+11±6%*	+62±22%*
SV vs. RV - type differences [%]	+67±19%*	+91±41%*	+70±34%*	+69±33%*	+66±29%*	+74±28%*

* Asterisk indicates a significant difference ($P < 0.05$)

RESULTS AND DISCUSSION

1. Type: With respect to the vibration type, the EMG activity was significantly ($P < 0.05$) enhanced during RV compared to SV in all recorded muscles (Table 1).

2. Frequency: Distinct differences were observed due to successively enhanced vibration frequency (Figure 2): the higher the frequency, the higher the EMG activity of all recorded muscles ($P < 0.05$).

3. Amplitude: An increasing amplitude resulted in an increase in EMG activity ($P < 0.05$, Table 1).

4. Body position: changing the knee angle from 10° to 30° to 60° resulted in successively increasing EMG activity in the knee extensors (RF +27%, +30%; VM +29%, +44%) and TA (+24%, +39%), whereas the EMG of Sol and GM was reduced. Forefoot stance resulted in significantly increased neuromuscular activity only for the plantar flexors (SOL +40%, GM +48%) compared to normal stance; however TA, VM and RF showed enhanced activation during normal stance (Figure 3).

Our analysis shows that each of the selected WBV parameters – frequency, amplitude type and body posture – have a considerable impact on the level of EMG activation in the leg muscles. Thus, the level of neuronal activation is highly dependent on the WBV parameter selection and can be expressed as a function of frequency, amplitude, and type or body posture.

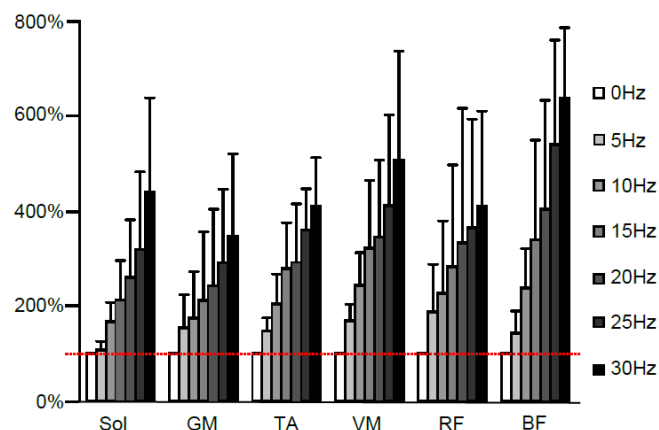


Figure 2: Changes in EMG activity due to progressively enhanced vibration frequencies: the higher the vibration frequency, the higher the EMG activity in all recorded muscles. As a reference, the horizontal red line marks the stance condition without WBV.

CONCLUSIONS

Our data show significantly different neuromuscular responses due to the variation of the WBV parameters within the given margins. Importantly, the findings of the present study support that an appropriate adjustment of specific WBV parameters provides high EMG activations in

the selected muscles and therefore high activation intensities can be achieved.

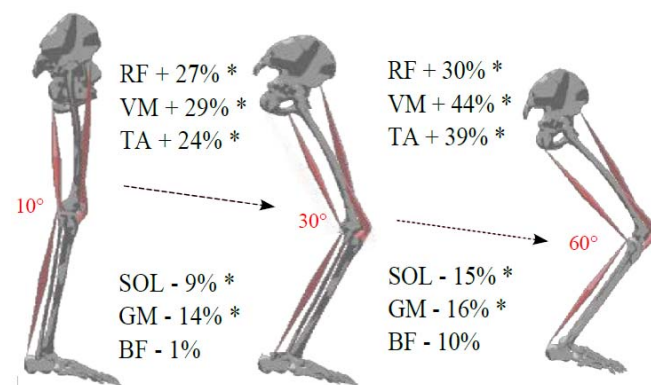


Figure 3: Changes in EMG activity changes in neuromuscular activation during WBV with respect to different knee joint positions.

Given that an optimal neuronal activation of a muscle is reflected by a high level of EMG activity [6], the following conclusions can be drawn based on the results motioned above:

The combination of a high vibration frequency and amplitude and on a rotational vibration platform is associated with the highest EMG activity during WBV exposure. Therefore, this combination is supposed to be the most efficient for WBV training purposes. Concerning the body posture, a knee flexion of 60° and normal stance conditions with the heels in contact with the platform seem to be most favorable for the knee extensor muscles. In contrast, forefoot stance and a nearly extended knee position is recommended for a specific training of the plantar flexor muscles.

ACKNOWLEDGEMENTS

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