Krause A[1,2], Ritzmann R[1], Lee K[1], Freyler K[1], Gollhofer A[1]

Acute Neuromuscular Modulation Enhances Postural Control after Whole-Body Vibration

Akute neuromuskuläre Modulation steigert die posturale Kontrolle nach Ganzkörpervibration

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1. UNIVERSITY OF FREIBURG, *Department for Sports and Sport Science, Freiburg, Germany*
2. GERMAN SPORT UNIVERSITY COLOGNE, *Institute of Training and Computer Science in Sport, Köln, Germany*

Summary

- **The postural movement control** determines performance of almost any kind of human movement. The current study aimed to investigate whether a short bout of whole-body vibration (WBV) can improve postural control. Effects were compared to a conventional balance training (BAL).
- **During an instable one-legged stance,** postural control was assessed in 22 healthy subjects before and after 2-min bouts of either WBV or BAL. Postural sway, antagonist co-contraction of selected lower limb muscles (soleus, gastrocnemius medialis, tibialis anterior, rectus femoris, biceps femoris) and soleus spinal excitability (H-reflexes) were recorded by means of posturography and electromyography, respectively.
- **Postural sway** was significantly reduced after WBV (p<.05). After both interventions, a reduction of H-reflexes (WBV -31%, BAL -14%, p<.05), M-waves (WBV -22%, BAL -19%, p<.05) as well as shank muscle co-contraction was observed (WBV up to -18%, BAL up to -20%, p<.05). Thigh muscle co-contraction was only diminished after BAL (-17%, p<.05). Postural sway changes correlated positively with reflex amplitude changes (p<.05).
- **Thus,** greater inhibition in spinal excitability (after WBV), but not diminished thigh muscle co-contraction (after BAL) are accompanied by postural sway reduction. With the benefit of being (task-) unspecific and easy to apply, WBV represents a possible intervention to improve postural control.

Zusammenfassung

- **Die posturale Bewegungskontrolle** bestimmt in nahezu jeder menschlichen Bewegung die motorische Leistung. Das Ziel der vorliegenden Studie war die Erfassung, inwiefern eine Einheit Ganzkörpervibration (WBV) die posturale Kontrolle verbessern kann. Die Effekte wurden mit einem klassischen Gleichgewichtstraining (BAL) verglichen.
- **Die posturale Kontrolle** wurde im monopedalem Stand bei 22 gesunden Proband*innen vor und nach 2-min Einheiten WBV oder BAL erhoben. Der posturale Schwankweg, die antagonistische Co-Kontraktion ausgewählter Muskeln der unteren Extremität (soleus, gastrocnemius medialis, tibialis anterior, rectus femoris, biceps femoris) und die spinale Erregbarkeit des Soleusmuskels (H-Reflex) wurden mittels Posturographie und Elektromyographie aufgezeichnet.
- **Der Schwankweg** war nach WBV signifikant reduziert (p<.05). Nach beiden Interventionen konnte eine Reduktion des H-Reflexes (WBV -31%, BAL -14%, p<.05), der M-Welle (WBV -22%, BAL -19%, p<.05) und der Co-Kontraktion im Unterschenkel beobachtet werden (WBV bis -18%, BAL bis -20%, p<.05). Die Co-Kontraktion im Oberschenkel war lediglich nach BAL reduziert (-17%, p<.05). Die Änderung des Schwankwegs korrelierte positiv mit den Änderungen der Reflexamplitude (p<.05).
- **Demnach** ging lediglich die stärkere Hemmung der spinalen Erregbarkeit (nach WBV), nicht jedoch die reduzierte muskuläre Co-Kontraktion des Oberschenkels (nach BAL) mit der Schwankwegreduktion einher. Mit dem Vorteil, dass die Modulationen (aufgaben-)unspezifisch und einfach zu applizieren waren, stellt WBV ein mögliches Interventionsgerät dar, mit dem die posturale Kontrolle verbessert werden kann.

KEY WORDS:
Balance, H-Reflex, Co-Contraction, Centre of Pressure

SCHLÜSSELWÖRTER:
Gleichgewicht, H-Reflex, Co-Kontraktion, Schwankweg

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CORRESPONDING ADDRESS:
Dr. Anne Krause
Lecturer and Research Assistant
German Sport University Cologne
Institute of Training and Computer Science in Sport, Am Sportpark Müngersdorf 6, 50933 Köln, Germany
: a.krause@dshs-koeln.de

Introduction

For any kind of human movement, the maintenance or acute restoration of postural control is of fundamental necessity (24). Balance training, which is known to improve postural performance (22), is therefore of particular relevance for sub-populations, who manifest deficits in motor control due to degeneration (e.g. elderly) or neurological disorders. In this regard, whole-body vibration (WBV) training has moved into the focus of scientific research, because it may enhance postural stability (28). 1) High-frequent mechanical oscillations of the platform cause perturbations applied to the body by means of instability (29), and thus 2) cause the muscle-tendon complex to dampen those forces transmitted to the body (5). This training modality makes WBV unique among

Table 1

Control parameters of test-retest reliability. Presented are angular excursions with goniometric recordings (Gonio [°], for the ankle joint (AJ) and knee joint (KJ)) and muscular background activation with electromyography (iEMG [%]). Cronbach's α are listed in the last column; values were compared to baseline values.

		PRE	CON & POST		A
Gonio [°]	AJ	67±8	CON	68±8	.97
			BAL	67±9	.97
			WBV	68±8	.94
	KJ	13±6	CON	12±7	.98
			BAL	12±6	.90
			WBV	14±6	.93
iEMG [%]	SOL	1.00	CON	.99±.09	.96
			BAL	.93±.15	.78
			WBV	.95±.15	.84
	GM	1.00	CON	.97±.16	.92
			BAL	.96±.23	.81
			WBV	.88±.16	.87
	TA	1.00	CON	.87±.26	.91
			BAL	.72±.21	.84
			WBV	.74±.21	.92
	RF	1.00	CON	.95±.11	.90
			BAL	.85±.13	.96
			WBV	.86±.15	.89
	BF	1.00	CON	.99±.13	.96
			BAL	.85±.12	.97
			WBV	.87±.11	.98

traditional balance training (BAL) methods. Characterized by a time-efficient and easy usage, especially patients who suffer from movement disorders might benefit from WBV (1). Nonetheless, evidence about the acute effects on postural control after WBV is still inconsistent and a conclusive statement is missing (4, 10).

From a neurophysiological point of view, postural control requires a complex interaction between sensory perception, central integration and motor execution (24). Therefore, excitability can be transferred via pathways which are originated from cortical structures of the central nervous system and are known to enhance motor control (corticospinal) as well as via pathways which are relevant in reflex motor responses (spinal). This neuromuscular interaction is highly adaptable, as could be demonstrated by conventional balance training: Reduced excitability via spinal pathways (37), enhanced input via corticospinal pathways (38) and an efficient intermuscular coordination of antagonists and agonists were observed (26). Acutely, the inhibition of spinal excitability correlates positively with enhanced postural stability; but modulations are only task-specific (25, 39). After vibration, similar modulations can be observed: exposure induces reduced muscle spindle sensitivity (30) and concomitant with the tonic vibration reflex (9) diminishes excitability via spinal (16, 33) and increases input via corticospinal pathways to the muscle (21). However, regardless of the resembling neuromuscular modulations after WBV compared to BAL, the impact of those neurophysiological correlates on postural control is vague.

From a mechanical point of view, WBV has an impact on neuromuscular control by applying sinusoidal forces to the body through the mechanical oscillation of the device (5). This occurs rather independent from the component interlinked to the postural demand (40). In comparison, balance training-induced improvements depend on the attributes of the performed balance exercise, i.e. degrees of movement and trajectory (14). Even though resembling modulation of Ia afferent pathways can be observed after both short-term interventions, neuromuscular effects are elicited by differing stimuli: The external (mechanical) stimulus of WBV can be opposed to the self-induced (physiological) stimulation of BAL.

Thus, the main purpose of the current study was to investigate, if acute neuromuscular modulation has an effect on postural control during a postural challenging task after WBV. We aimed to identify if the training stimulus acts on spinal reflex activity and antagonistic muscle co-contraction and whether these neuromuscular modulations attribute to changes of postural sway.

Based on evidence about positive functional effects after WBV, we hypothesized that postural control by means of reduced postural sway might be improved following a short bout of WBV. We assumed reflex responses to be inhibited after WBV during a postural challenging task, introducing positive effects on postural control.

In addition, we aimed to test the dependency of results from the stimulus itself. Therefore, we also conducted a conventional balance task which is known to improve postural control in a task-specific manner. Thus, based on the strong mechanical stimulus, changes in postural control were expected to be greater after WBV compared to BAL.

Methods

Participants

Twenty-two young, healthy subjects (17 females/5 males, 25±2 years of age, 169±8 cm height, 62±12 kg body mass) participated in this investigation. Inclusion criteria comprised the ability to balance on a wooden wobble board in a one-legged stance. Participants were excluded in case of acute or chronic orthopaedic injuries or neurological disorders. All participants gave written informed consent to the experimental procedure, which was in accordance with the latest revision of the Declaration of Helsinki and approved by the ethics committee of the University of Freiburg (197/17).

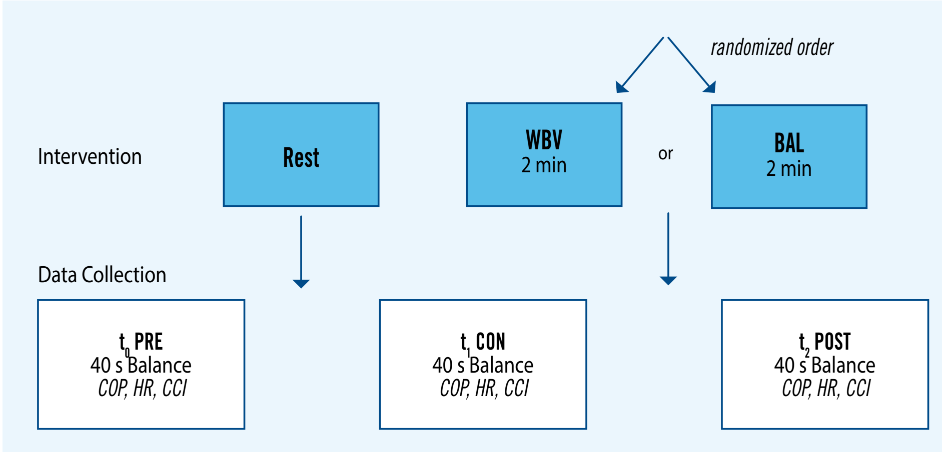

Figure 1

Study design of 2-min bouts of whole-body vibration (WBV) or a conventional balance task (BAL).Two pre-measurements (PRE/ t_0, CON/ t_1) were conducted to test for test-retest reliability. At each assessment point, the outcome measures centre of pressure (COP), spinal excitability (H-reflexes, HR) and co-contraction (co-contraction index, CCI) were recorded during 40 s of a balance task.

Experimental Design

In a repeated-measures cross-sectional study design, parameters of postural control were tested prior and after 2-min short-term interventions of either WBV or BAL in a randomized order (Fig. 1). Assessment of postural control was conducted while balancing in a one-legged stance on the wobble board (37). Postural sway, agonist-antagonist muscular responses (co-contraction) and spinal excitability were recorded. The duration of one trial lasted 40s with the application of ten electrical H-reflex stimulations. Participants were instructed to stand as still as possible in an upright position (14). Head and eyes faced in forwards position, the contralateral leg was flexed at 90° in the knee, but extended in the hip (14). They trained prior to the first assessment to exclude habituation effects(14). For test-retest reliability, authors supervised standardized body position at all times and the exact same assessment was conducted twice prior to the first intervention (control assessment, CON) (21). In case of balance loss, the trial was repeated.

Due to an unreliable body position characterized by differences in ankle joint position measured by electrical potentiometers, one participant was excluded from data analysis.

Short-Term Interventions

Participants balanced either on a vertical side-alternating vibration platform (Galileo Sport, Novotec Medical, Pforzheim, Germany) or on the wobble boards (14, 39) for two minutes intermittently (5, 36; see Fig. 1). Each trial was repeated twice with short breaks in-between to prevent fatigue. Identical to the assessment, participants stood in an upright one-legged position. Training protocols were matched to exclude confounding effects due to volume, duration or body position, with the only exception of a nearly extended knee and slightly lifted heel to reduce vibratory stimuli to the upper body according to previous results (21) (4mm peak-to-peak displacement, 11cm from rotation axis, peak acceleration 7.2g).

Data Collection

Postural sway. Three-dimensional forces and torques were recorded with a force plate (Novotec Medical GmbH, Pforzheim, Germany) located under the wobble board with a frequency of 50Hz. Centre of pressure displacements in anterior-posterior (COP^{ap}) and medio-lateral direction (COP^{ml}) were assessed in addition to the total displacement (COP^{t}).

Kinematics. Angular position in the ankle and knee joint in the sagittal plane was assessed with custom-designed electro-goniometers (Biometrics®, Gwent, UK). The rotary potentiometers (Megatron, Munic, Germany) were fixed over the respective joint with rotation axes and movable endplates in line with the longitudinal body axes (33). Neutral position for the ankle joint was set at 90° between the endplates and for the knee joint at 180°. Data were recorded with a sampling frequency of 1kHz.

Electromyographic recordings. Muscular responses of five selected lower limb muscles (SOL–soleus, GM–gastrocnemius medialis, TA–tibialis anterior, RF–rectus femoris, BF–biceps femoris) were recorded with surface electromyography (EMG) according to SENIAM (17). Hair over the muscle belly was shaved, skin slightly emerised and degreased. Bipolar Ag/AgCl surface electrodes (Ambu Blue Sensor P, Ballerup, Denmark; diameter 9mm, centre-to-centre distance 25mm) were placed in line with the muscle fibres and over the tibia (reference electrode) with an interelectrode resistance below 2.5kΩ. Data were transferred to the amplifier (sampling frequency of 1000Hz) and band-pass filtered (10Hz-1kHz).

Prior to the experimental session, trials to assess the maximal isometric voluntary contraction (MVC) were conducted to establish each muscles' maximal activation intensities based on Daniels and Worthingham (8). Maximum contractions of three seconds were used for normalization. Body position and antagonistic muscle activity were standardized and controlled strictly.

Spinal excitability. With the technique of Peripheral Nerve Stimulation, muscular responses were elicited with 10 electrical stimulation of the tibial nerve (Digitimer DS7, Digitimer, Welwyn Garden City, UK) and recorded with EMG electrodes over the SOL. A cathode (10x5cm dispersal pad) was placed over the tibial nerve in the popliteal fossa and an anode below the patella (2cm diameter). Squared-wave pulses of 1ms were applied with 4s interstimulus intervals. With the exception of CON, which was conducted for reliability reasons, each protocol was conducted twice resulting in 20 stimuli for each condition.

Table 2

Acute effects after short-term interventions of BAL and WBV. Postural sway (centre of pressure, COP) and neuromuscular raw data (co-contraction index, CCI and spinal excitability/ H/M-ratios) are depicted before (pre) and after (post) a 2-min bout of balance (BAL) or whole-body vibration training (WBV). A control condition (CON) was applied prior to BAL and WBV. Significant values are depicted in bold letters with p<.05. Effect sizes according to Glass' Δ are described in the last column.

		PRE	CON & POST		P-VALUE	GLASS' Δ
COP [cm]	COP_{ap}	12.54±3.78	CON	11.91±2.78	.58	.23
			BAL	11.96±2.76	.29	.21
			WBV	11.56±2.47	.05	.40
	COP_{ml}	12.34±3.12	CON	11.64±3.73	.21	.19
			BAL	12.36±2.84	1.46	.01
			WBV	12.03±2.08	.48	.15
	COP_t	19.58±5.09	CON	18.56±4.41	.09	.23
			BAL	19.10±4.03	.67	.12
			WBV	18.61±3.03	.18	.32
CCI [arb. unit]	SOL_TA	1254±432	CON	1226±445	1.18	.06
			BAL	1002±405	< .01	.62
			WBV	1017±380	< .01	.62
	GM_TA	1481±658	CON	1437±662	1.43	.07
			BAL	1268±673	.01	.32
			WBV	1215±623	<.01	.43
	RF_BF	414±271	CON	392±268	.62	.08
			BAL	352±292	.02	.21
			WBV	380±281	.17	.12
H^{SOL} [mV]	M-wave	.36±.40	CON	.31±.36	.45	.13
			BAL	.26±.34	.05	.29
			WBV	.25±.38	.02	.29
	H-reflex	.56±.27	CON	.58±.32	1.63	.08
			BAL	.47± .22	.01	.40
			WBV	.38±.25	<.01	.71

Stimulus intensity of 25% of the individual maximal muscle response (6) was assessed with an H/M-recruitment curve during bipedal stance prior to the first measurement(33).

Data Processing

For all outcome measures, mean values and standard deviations were calculated.

Postural Sway

Total COP path length (COP_t) was calculated according to the Pythagoras theorem with COP_{ml} and COP_{ap} in a time window of 20s: $COP_t = \Sigma D_i$, i=(0; 20000) with D_i=[(Displacement in anterior-posterior axis)^2+(Displacement in medio-laterlal)^2]^{½} for each sample point (32).

Electromyographic recordings

MVC values were analyzed in a time window of 50ms after maximal EMG amplitude. Background activity was assessed 100ms prior to each electrical stimulus. Raw EMG values were rectified and integrated (iEMG[mVs]).

For the quantification of co-contraction, data were analyzed starting at the first H-reflex stimulus and with a time window of 20s while balancing on the wobble board. After normalization to MVC values, co-contraction indices (CCI) of the antagonistic muscle pairs CCI^{SOL_TA}, CCI^{GM_TA} and CCI^{RF_BF} were calculated as follows: $CCI=\Sigma CCI_i$, i=(0;20000) with CCI_i=(EMG_i of lower activated muscle/EMG_i of higher activated muscle)x (EMG_i of lower activated muscle+EMG_i higher activated muscle) for each sample point (23).

Spinal Excitability

Peak-to-peak SOL M-wave and H-reflex amplitudes were evaluated between the initial deflection of the EMG signal from baseline to the second crossing of the baseline as described previously (33). We summarized the differences between maximum peak of H_{BAL}-H_{WBV} (Δ1) and between minimum peak of H_{BAL}-H_{WBV} (Δ2) to calculate total amplitude differences (HΔ; Fig. 2).

Statistics

Changes over time were analyzed with two dependent variables (pre vs. post): Normal distribution was determined with Shapiro-Wilk test. Based on those results, either Student's paired t-test or the non-parametric Wilcoxon Rank-test were calculated. Data were corrected for multiple testing based on Benjamini and Yekutieli (3). Effect sizes over time were analyzed with Glass' Delta (Glass'Δ) (11). Additionally, either Pearson or Spearman's rank correlation coefficient were calculated for the comparison of COP and H-reflex pre-post-differences. Reliable background activity and joint position were ensured with Cronbach's α values (12).

Results

Cronbach's α estimates yielded excellent values for the ankle and knee joint position (.90-.98) and good to acceptable values for muscular background activity (.78-.98; Table 1) indicating a reliable body position and neuromuscular activation throughout the measurement. Neither functional (postural sway, Glass'Δ=.19-.23) nor neuromuscular outcome measures (antagonistic co-contraction Glass'Δ=.06-.08, spinal excitability Glass'Δ=.08-.13) changed over time when no training was applied (CON; Table 2).

In line with CON, postural sway did not change after BAL (p=.29, Glass'Δ=.21), but was significantly reduced after WBV for COP_{ap} (p<.05, Glass'Δ=.40).

In contrast to CON, effects for co-contraction (cf. Table 2) were observed after both training modalities: CCI_{SOL_TA} values ranged between -17±19% (p<.01, Glass'Δ=.62) and -20±15% (p<.01, Glass'Δ=.62), CCI_{GM_TA} values between -18±17% (p<.01, Glass'Δ=.43) and -14±23% (p<.05, Glass'Δ=.32) for WBV and BAL, respectively. In addition, co-contraction in thigh muscles (CCI_{RF_BF}) was diminished by -17±26% after BAL, only (p<.05, Glass'Δ=.21; Table 2).

For spinal excitability, significant effects were observed in comparison to CON as well: H-reflexes were diminished by -31±30% after WBV (p<.01, Glass'Δ=.71) with greater effect sizes than after BAL with a reduction of -14±25% (p<.05, Glass'Δ=.40; Fig. 2). Additionally, M-waves were diminished as well; values of -22±34% after WBV (p<.05, Glass'Δ=.29) and -19±36% after BAL were assessed (p<.05, Glass'Δ=.29; Table 2).

Comparing WBV to BAL, reduced H-reflexes correlated significantly with diminished COP_{ap} (r=.472, p<.05; Fig. 3) and COP_t (r=.538, p<.01).

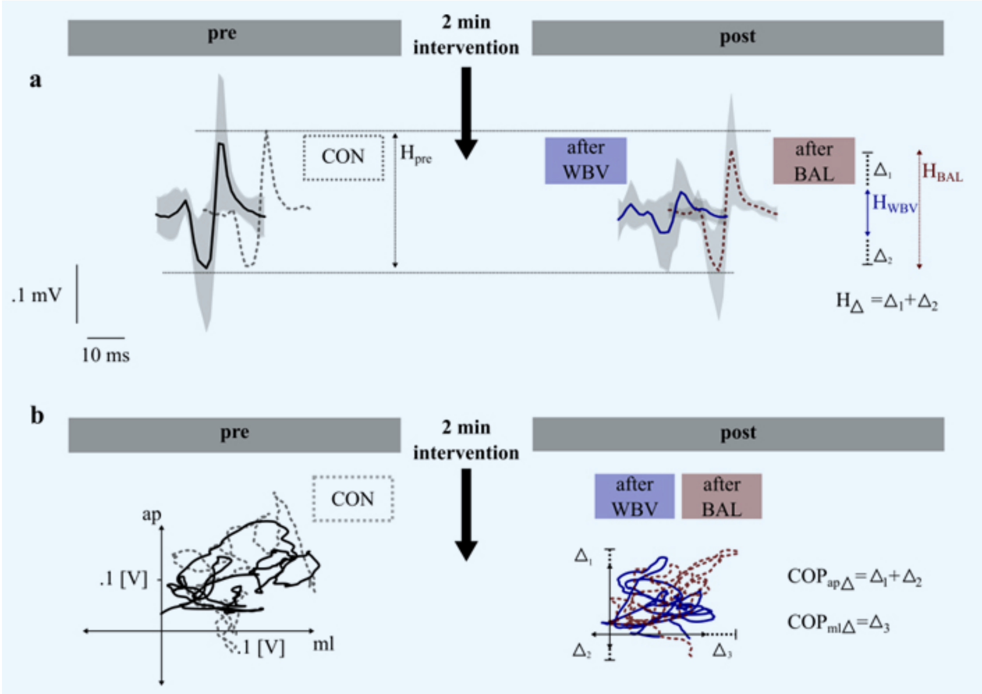

Figure 2

Postural sway and reflex activity prior and after short-term interventions of one representative participant. Changes of Hoffmann- (H-) reflex amplitudes are depicted in the upper (a) as well as centre of pressure displacement in anterior-posterior (ap) and medio-lateral (ml) direction in the lower part of the figure (b). Measurements were conducted twice prior (PRE=solid line; control, CON=grey dotted line) as well as after either whole-body vibration (WBV=blue line) or after conventional balance training (BAL=red dotted line). For PRE, WBV and BAL, standard deviations are illustrated in grey. Next to the evaluation of pre-post changes, differences between effects after WBV and BAL were compared and are depicted with Δ.

Discussion

The aim of the current study was to investigate acute effects of WBV on postural control by means of neuromuscular parameters and functional effects on postural sway. In comparison to conventional balance training, we demonstrated for the first time that neuromuscular control during a postural challenging task was modulated after both, a short 2-min bout of WBV and BAL. However, differences in motor control resulted just partly in a verification of our hypotheses:

1) After WBV, a reduced postural sway in anterior-posterior direction was accompanied by a decline in spinal excitability and co-contraction in the shank muscles. After BAL, there were no changes in postural sway, but antagonist co-contraction in shank and thigh muscles declined. 2) Comparing the selected interventions, greater effect sizes were reached for changes in postural sway and spinal excitability after WBV and in muscular thigh co-contraction after BAL. The electrophysiological findings correlate with COP displacement indicating an interrelationship between balance performance and neuromuscular function.

Task-Specificity

First, the reduction of postural sway following a short bout of WBV is in accordance with previous results and might indicate enhanced postural control (35). In the current study, sway in anterior-posterior direction moves into focus. Even though it could be assumed that side-alternating vibration might induce a lateral stimulus, and thus modulation of COPml, previous investigations have shown that muscles which are involved in the anterior-posterior sway (SOL, GM and TA) are activated to a greater degree compared to synchronous vibration(34). By decreasing muscular activation in those specific muscles around the ankle joint, self-induced perturbation might be reduced, and thus COP^{ap} sway decreased as well.

In addition, this observed outcome of postural sway after WBV was connected to neuromuscular effects for the first time: As introduced earlier, both, WBV and BAL elicit stretch reflexes via the Ia afferent circuitry, either via the external (mechanical) vibration-induced or the self-induced (physiological) task-specific stimulus. While the reflex reduction after BAL is in accordance with previous investigations (39), ›

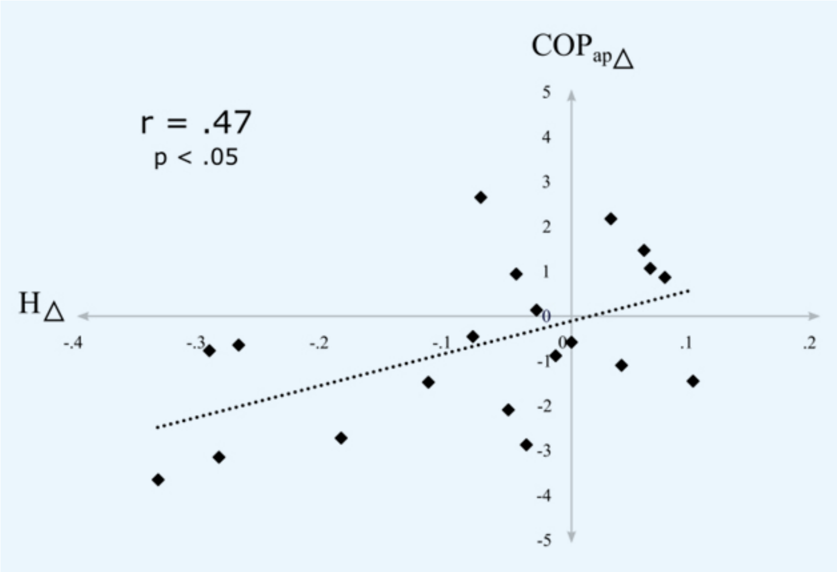

Figure 3

Linear relationship between differences of WBV compared to BAL of postural sway and reflex activity. Correlation coefficient (r) between postural sway ($COP_{ap\Delta}$) and spinal excitability (H_{Δ}) were calculated as described in Figure 2.

inhibition of spinal excitability after WBV has been demonstrated during rest or voluntary activation (16, 33). We could add that this inhibition is also reflected during a postural demanding task: The improved balance control is interrelated to the degree of reflex inhibition clearly indicating the functional significance of the WBV-induced decline in Ia afferent transmission. Reduced reflex responses have previously been identified with improved balance control by means of diminished joint oscillations in young populations (19, 20, 37). This modulation is assumed to be of supraspinal (subcortical) origin (37, 38) resulting in improved movement control. While WBV is known to enhance corticospinal excitability (21), the current results support the assumption of improved movement control following WBV. Beyond WBV, two possible reasons could be stated to explain, why postural sway was not diminished after BAL as it has been observed in previous studies (25): First, we included subjects with a high level of postural control in contrast to previously investigated elderly participants (25). Second, the magnitude of spinal excitability inhibition is smaller after BAL compared to WBV. Therefore, the mechanical stimulus might elicit even greater changes in reflex responses compared to the physiological stimulus.

Muscle-Specificity

In addition, shank muscle co-contraction was reduced after both interventions. As has previously been reported, greater activation of antagonistic muscle groups is related to lower postural ability resembling an "older adult" strategy during postural and overall motor control (27). Vice versa, in previous balance intervention studies, reduced muscular activation, which is assumed to be due to improved intermuscular coordination, was observed concomitant with functional reduction of postural sway (15). In line with this, current acute neuromuscular effects were also evident concomitant with a decrease in postural sway, and thus point towards improved postural control (26). Especially distal muscles surrounding the ankle joint move into focus (13): After BAL, co-contraction in thigh muscles was reduced as well, but this was not reflected in a functional significant reduction of postural sway. This is in line with previous investigations, which demonstrated a relationship between muscles surrounding the ankle joint and the compensation of postural perturbations in anterior-posterior in contrast to medio-lateral perturbations (13). To be more distinct, this segment-specific modulation can be narrowed down to muscle-specific effects in the m. triceps surae: After WBV, postural sway concomitant with co-contraction was reduced for CCI_{SOL_TA}, only. While SOL and TA are the muscles that are closest to the destabilizing stimulus (vibration) or pivot (wobble board), these muscles move into focus when considering modulation of postural control after WBV.

Limitations

In our current investigation, we could specify the importance of muscles directly surrounding the ankle joint. While we chose antagonistic muscle pairs based on previous evidence (18, 31), we could not exclude the impact of muscle groups such as lateral leg and trunk muscles. Due to their relevance for postural stabilization(2), further evidence about their involvement in balance tasks after WBV is still needed.

In addition to that, even though body position was kept reliably constant, direct motor responses (M-waves) were slightly affected in the current postural assessment settings. While recent results include either reduced muscular responses (15) or no changes during rest after vibration (33), those results might point towards a modulated excitability of efferent pathways. Changes of M-waves due to fatigue are unlikely due to constant M-waves during the control condition. This is also why inhibition due to the long-lasting duration (7) or habituation effects can be excluded for the current changes. However, effect sizes of reflex activity (H-reflex) exceeded those of direct muscle responses (M-wave) after WBV, demonstrating effects on spinal circuitries nevertheless. Based on those neuromuscular effects during static balance tasks, it is going to be imperative to examine if modulations can be transferred into tasks of dynamic postural control and in a population suffering from poor postural stability.

Conclusion

Acute exposure to WBV has a positive impact on postural control in anterior-posterior direction beyond the effects of BAL. With a major contribution of diminished spinal excitability and shank muscle co-contraction, WBV can be used to acutely modulate neuromuscular control during postural demanding tasks. Especially populations suffering from postural instability based on enhanced co-contraction and spinal hyper-excitability might benefit from those acute modulations.

However, further evidence is needed to investigate the transfer into everyday life tasks. Therefore, the modulation during dynamic postural control and the maintenance of those acute modulations might be of great relevance. While previous investigations point towards sustaining neuromuscular effects for 10-15min following WBV, the application of WBV training immediately prior to postural instable situations might be of great relevance for long-term fall prevention.

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Conflict of Interest

The authors have no conflict of interest.

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