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Original Article

Stochastic Resonance Whole-Body Vibration, Musculoskeletal Symptoms, and Body Balance: A Worksite Training Study

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Background: Stochastic resonance whole-body vibration training (SR-WBV) was tested to reduce work-related musculoskeletal complaints.
Methods: Participants were 54 white-collar employees of a Swiss organization. The controlled crossover design comprised two groups each given 4 weeks of exercise and no training during a second 4-week period. Outcome was daily musculoskeletal well-being, musculoskeletal pain, and surefootedness. In addition, participants performed a behavioral test on body balance prior to when SR-WBV started and after 4 weeks of SR-WBV.
Results: Across the 4-week training period, musculoskeletal well-being and surefootedness were significantly increased ($p < 0.05$), whereas musculoskeletal pain was significantly reduced only in those who reported low back pain during the last 4 weeks prior to the study ($p < 0.05$). Body balance was significantly increased by SR-WBV ($p < 0.05$).
Conclusion: SR-WBV seems to be an efficient option in primary prevention of musculoskeletal complaints and falls at work.

1. Introduction

A recent study on musculoskeletal complaints (MSC) showed high 1-month prevalence rates in office workers mostly between 10% and 30 % when values from 18 countries were compared [1]. Thereby, MSC cause absenteeism and to an even larger extent presenteeism that increases labor costs [2]. Work-related prevention of MSC therefore becomes an increasingly important goal [3]. Waddell and Burton [4] proposed that it should be possible to reduce MSC-related sickness absence and long-term incapacity by at least 30–50%, but this would require a fundamental shift in management culture. Part of this shift is occupational health promotion that includes work hardening efforts [5]. The problem of many worksite activity trainings, however, is low participation rate and a lack of compliance with training [6,7]. Compliance suffers because participants often have to invest more than 20 minutes for a training session [8], take further time prior to training to commute to other places in work, have to change clothes prior to training and after training, to complete their warming-up and cooling down, or to take a shower. By contrast, stochastic resonance whole-body vibration training (SR-WBV) is low in nonmonetary effort when compared to conventional exercise: SR-WBV has very short exercising duration (about 10 minutes), is easily carried out in work settings, and no change of clothes is necessary. The objective of this study was to investigate possible preventive effects of SR-WBV on MSC in white-collar workers doing office work.

1.1. Stochastic resonance whole-body vibration training

SR-WBV is whole-body vibration training with randomized vibration. Because the vibration is stochastic, the direction and the force-time behavior of the vibrations are not foreseeable and the body will be constantly challenged to adapt the muscle reactions [9–11]. SR-WBV seems to provoke an interaction of different types

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of neurophysiologic sensors and the adjustment of afferent and efferent signals, possibly acting as "training" for the sensorimotor system [9], even more so than other conventional sinusoidal vibration [12]. A strength increase is mainly attributed to neural adaptation, leading to improved intermuscular and intramuscular coordination, allowing increased activation of prime movers in specific movements and better coordination of the activation in all relevant muscles [13]. A low injury risk and the only rare appearance of side effects make whole-body vibration training an interesting preventive intervention [14,15]. There is evidence that stochastic whole-body vibration training can reduce musculoskeletal pain in metal manufacturing workers who were exposed to biomechanical risk factors [16]. However, musculoskeletal pain is also highly prevalent in office workers who perform sedentary work at video display units [17]. Risk factors in sedentary work include lack of posture change and psychosocial work risk factors such as mental stressors (e.g., time pressure and performance constraints) [3]. Thus, the current study tests the effectiveness of SR-WBV in employees doing sedentary office work. We expected SR-WBV to reduce MSC in terms of pain and increase musculoskeletal well-being (Hypothesis 1). Evidence indicates that training effects of SR-WBV include gain in postural control [18–20], although the physiological mechanism behind it is unclear so far [11]. Therefore, it was hypothesized that SR-WBV might help to increase postural control as shown in an increase in reported surefootedness—as a measure of perceived body balance—and balance performance in a standard behavioral balance test (Hypothesis 2).

In addition to a general positive effect of SR-WBV on MSC, surefootedness, and body balance, we suggested a particular positive effect on those who had low back pain in the 6 months prior to when the training started. In these employees SR-WBV was suggested to have a therapeutic effect in addition to the general training effect. Both, SR-WBV training efficiency [21] and therapeutic effects [15] were summarized recently. Thus, in Hypothesis 3 we expected those who currently or recently suffered from low back pain to show more intense training effects than others.

2. Materials and methods

2.1. Participants

Participants were employees from a Swiss organization in manufacturing systems engineering in aviation. All employees ($N = 313$) doing office work within the organization were asked to participate in the study. Of 313 employees, 58 (18.5%) agreed to participate. Four participants had to be excluded because of health risks. Exclusion criteria were: acute, past, or chronic arthropathologies; cardiovascular disease; psychopathology; spondylolysis; spondylolisthesis; tumors; prolapse with neurological failure; rheumatism, articular gout; osteoporosis; activated arthrosis with inflammatory signs; stage 4 arthrosis; pregnancy; knee or hip replacement; or electronic implants. Of the remaining sample of 54 participants, 51 were employed full time. Two participants worked an 80% time schedule (4 days a week) and one participant had a 70% work schedule (3.5 days a week). Age was between 18 years and 61 years [mean = 39.8 years, standard deviation (SD) = 10.4]. The sample consisted primarily of men (85.2%), reflecting the sex ratio in the total personnel of the organization. The average tenure for participants was 7 years. Educational level was high, with most participants (60%) having a university degree. Body mass index was 24.4 on average (SD = 2.8). Mean height was 1.78 m and mean weight was 78 kg. Participants did not receive medical treatment during the study.

The 54 volunteering employees were randomly assigned to two groups with balance for work field and few *a posteriori* adjustments for planned vacation, to prevent absences during exercises. Randomization was based on using a list of random numbers [22]. The resulting two groups of 27 participants each did not differ substantially in demographic characteristics, frequency of low back pain episodes over the 6 months prior to SR-WBV, and values of outcome variables on Day 1 of the study.

2.2. Design and procedure

In April 2009 all 313 employees doing office work within the organization were informed about the aim of the present study. The study goals were introduced as addressing organizational health. SR-WBV was characterized as a method to be tested to enhance physical fitness. Participants were informed about their rights including the right to stop the training whenever they wanted. Participants were given a guarantee of anonymity. All participants provided informed consent prior to their inclusion in the study. The study was performed in consensus with recommendations outlined by the Declaration of Helsinki and with all requirements defined by the Swiss Society of Psychology. The ethical committee of the responsible university faculty has approved the study proposal (Proposal No. 2009-04-0006).

The research design was a switching-replication design with randomized group allocation of participants ("randomized controlled crossover design"). The training of all participants was divided into two periods, both lasting 4 weeks. In the first period, Group A trained on a SR-WBV device three times a week whereas group B received no treatment (waiting group). After 4 weeks Group B received SR-WBV, whereas group A received no treatment. The exercises were completed at the place of work.

2.3. Stochastic resonance whole-body vibration training

A special device, the SRT-Zeptor Medical plus noise (FreiSwiss AG, Zurich, Switzerland), was used for the vibration treatment (Fig. 1). Its main features are two independent, one-dimensional (up/down) stochastically oscillating footboards (3 mm amplitude), with two passive degrees of freedom (forward/backward, right/left). In addition to vertical and horizontal actions the platforms also allow medial and lateral tilting, which leads to a pluridimensional movement.

All exercising sessions were supervised. Participants were instructed to stand on the footboards with the arms hanging loose to the side and slightly bent knees (i.e., a skiing posture). The vibration frequency in each 60-second session started with 5 Hz, and after the start of the training session participants could regulate the frequency within a range of between 4 Hz and 8 Hz by themselves. A session consisted of three sets, lasting 1 minute each, with a 1-minute break in between. All sessions were conducted at the beginning of the work shift between 6:00 A.M. and 8:00 A.M. Two participants shared an exercising session, so that when one person was having the 1-minute break, the other could exercise. Three such sessions per week were planned for each person. This setting was the same as used by Burger and colleagues [16] in a study on metal manufacturing workers. The goal of performing 12 training sessions in the 4-week training period was reached for most participants. The individual number of sessions absolved ranged between 9 and 14 (mean = 11.7, SD = 0.8). The chosen frequencies had a mean of 6.4 Hz (minimum = 4 Hz, maximum = 8 Hz, SD = 0.7 Hz).

Sex, age, body weight, body height, and low back pain in the previous 6 months were assessed in a baseline questionnaire prior to the start of SR-WBV. Low back pain was assessed with one item of the Nordic Questionnaire [23]. The item asked for frequency of