ACUTE EFFECTS OF WHOLE BODY VIBRATION TRAINING ON THE RANGE OF MOVEMENT AND THE MUSCULAR FUNCTION OF THE LOWER LIMBS OF THE SOCCER PLAYER

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Abstract
The basic aim of this study was to determine the acute effects whole body vibration training applied in static stretching exercises, on the range of movement and the muscular function of the lower extremities in the soccer players. For this purpose, footballers (N = 34) were engaged, chronologically aged 20-24. The vibration (experimental) protocol (VSI) implied the practice of static stretching performed on the included vibrational platform (f = 40 Hz, A = 2 mm), while the standard protocol (SSI) implied performing the same exercises but with the vibration platform off. The results of the t-test demonstrated that the vibration protocol (VSI) can contribute to a significant (acute) improvement lower extremity passive range of motion compared to the standard (SSI) protocol. However, there were no statistically significant differences between the applied protocols (SSI and VSI) on the variables for the assessment of muscular function (vertical jumps and sprints). The results of this study indicate that the whole body vibration training applied in static stretching exercises effectively improves the range of movement of lower limbs, but not the muscular function measured by the types of vertical jump and maximum sprint test, in acute settings.
Keywords: *soccer players, vibration training, acute effects, static stretching, muscular function*

INTRODUCTION

In the training process, athletes usually perform various warm-up activities to prepare for greater exercise intensity. Such activities are often used before the competition or training to optimize sports performance, increase body temperature and flexibility, and stimulate more metabolic changes (Fradkin et al., 2010). Generally, two modes of warming can be used in sports: passive (elevation of body temperature by exogenous factors), and active (elevation of body temperature by physical exercise) (Bishop, 2003). When it comes to active warm up, then introductory pre-preparation is usually carried out through three typical common parts. In the first place, there are different aerobic activities of low intensity to increase optimal body temperature to improve nerve-muscle function (McArdle et al., 1991). Then, using different methods follows a specific stretching of the muscle (mostly dynamic or static) that should be engaged with the main load, and as a last stage there is the training of specific movement tasks, with the intensity that can sometimes exceed the main training load. When it comes to stretching exercises, most coaches recommend using static stretching exercises with the idea that it helps to reduce the risk of injury caused by training or competition. However, methods for optimally increasing flexibility, while looking at the long term, are currently under a scientific debate. One of the recent studies has been trying to answer a multiannual controversial issue of the acute effects of static stretching on the work ability of a athlete. In a meta-analytical article, scientists (Šimić et al., 2013) analyzed and summarized the results of more than a hundred previous studies that studied the acute effects of static stretching as an exclusive warm-up exercise before exercise and used sophisticated statistical calculations to determine how much stretching affects the athlete excercise effect. The research resulted in the recognition that static stretching, if it represents the only form of warm-up before training, significantly acute (currently) reduces the strength, power and motor performance of the athlete regardless of his age, gender or level of training (Šimić et al., 2013). This has confirmed that static stretching can reduce the sprint and jumping performance. However, the simultaneous combination of static stretching and vibration training might overcome this type of problem. Vibrating training could be an adequate modality to increase flexibility, while not disturbing, or even improving the neural muscular function. This is a relatively new training technology, and the latest training form is known as the WBV (whole body vibration training), which is fully used on the vibrational platform (Marković and Gregov, 2005). While the traditional view that vibration can carry a high risk of harm, more and more studies put their focus on the positive effects of this mode of training (Rittweger, 2010). It is often argued that muscle strength improvements in or immediately after the application of vibration are associated with nerve-muscular facilitation (Cochrane et al., 2004; Delcluse et al., 2003; Issurin and

Tenenbaum, 1999). There seems to be more sense to attribute acute muscle strength improvements to well-documented warming effects when applying this type of training when friction between vibrating tissues can cause muscular temperature increase (Issurin et al., 1999), together with increased blood flow (Kerschan et al ., 2001). With this, vibration training is increasingly used as a means of warm up modality, due to its time efficiency. With the trace of this finding, it could be assumed that vibrational training can carry a synergistic effect that would be reflected not only through an acute increase in range of movement (flexibility) due to increased temperature of exposed musculature, but also to the improvement of the neuromuscular function measured by increased muscular strength (Cochrane and Stannard, 2005).

MATERIALS AND METHODS

Subjects

For the purposes of this study, the participanst was made up of athletes, football players (N = 34), chronological age 19-24 years. None of the subjects in the selected sample had reported any of the chronic illnesses, nor did they have any medical contraindications, closely related to the practice of vibrational training. The acute part was performed by all participants (N = 34). Table 1. presents the basic descriptive parameters of all selected entities within the sample (N = 34), which relate to chronological age, body weight, and adipose tissue parameters expressed in percentages.

Table 1. Basic morphological characteristics of the selected sample

Participants body composition					
	N	Min Value	Max Value	Mean Value	Standard Deviation
CHRONOLOGICAL AGE	34	19	24	20.9	1.5
BODY HEIGHT	34	169	186	178.7	4.0
BODY MASS	34	62.6	92.6	76.2	5.9
FAT MASS %	34	6	15	11.0	2.5

Study design

All participants are randomly divided into two equal groups (SSI and VSI). The vibration (VSI) protocol was made of 5 static stretching exercises on the vibration platform (f = 40 Hz, A = 2 mm, t = 30 s stretching / 5 s with relaxation). The standard (SSI) protocol was performed equal as vibrational, with the exception that all stretching exercises are performed on a disconnected device. Prior to conducting one or the other protocol, each participant conduct a low moderately continuous running for 5 minutes. A randomized crossover experimental design was used to determine acute effects. Finally, during both test days (48 hours between), all participants (N = 34) passed both protocols. Immediately (1 minute) at the end of one or another protocol, the first measured variables were for the evaluation of the power abilities (jumps and sprints), and then the variables for the evaluation range of movement of the lower limb (only dominant leg). Vibration training was conducted on vibration platform, German manufacturer Powrx, model Pro Evolution 2.7. Five vibration exercises are selected for the purpose of this study: static stretching in the front lunge, static stretching in the lateral lunge, static stretching in the dorsal flexion (foot) position, static stretching in the trunk flexion position, static stretching in the rear lunge, in that order.

Testing procedures and instrumentation

The range of movement of the lower limbs was measured by the goniometer (Baseline Goniometers, 12-1240: 12", 360 °, USA), and the following variables are used only for dominant leg: passive hip flexion (straight leg test), passive hip extension, passive plantar flexion, passive dorsal flexion. To acces explosive power, we used a squat jump and countermovement jump, without the active engagement of the upper limbs. To assess the explosive power in running, a specific football test sprint was used, which was conducted at a distance of fifteen meters (Browers Timing System, IRD-T175, USA). As a set of activation exercises, five static stretching exercises was used on the vibrational (Powrx, Pro Evolution 2.7) platform (VSI protocol) and five equal exercises conducted without vibrational stimuli (SSI protocol).

Statistics

All of the results were anylized using SPSS 20 for Microsoft Windows platform (SPSS Inc., Chicago, IL, USA). For all dependent variables standard descriptive parameters are calculated: mean value and standard deviation. For the purposes of this study, Student's t-test of paired samples was used.

RESULTS

Table 2 presents basic descriptive parameters (MV and SD) for each dependent variable measured immediately after SSI and VSI protocols. Table 2 also indirectly compares the differences in dependent variables after two applied protocols (measured immediately) expressed in percentages, with the added value of the t-test performed.

Table 2. Mean values (MV), standard deviations (SD) of participants for all dependent variables after both protocols. Differences between SSI and VSI protocols (%), with T-test values (statistical significance level: (* p <0.05)

SSI protocol post-test (n=34) MV ± SD		VSI protocol post-test (n=34) MV ± SD	*Differences between SSI and VSI protocols*
Hip flexion	95.6 ± 6.7	100.4 ± 13.7	5%*
Hip extension	27.8 ± 2.7	30.6 ± 3.5	10%*
Plantar flexion	47.9 ± 3.7	51.4 ± 3.4	7.3%*
Dorsal flexion	19.7± 1.6	26.1 ± 2.9	32.4%*
Squat jump	32.6 ± 4.2	33.4 ± 3.9	2.4%
Count mov jump	34.6 ± 4.0	35.0 ± 3.9	1.1%
Sprint on 15m	2.49 ± 0.11	2.48 ± 0.10	0.40%

From Table 2 it is noticeable that the average results on the variables for estimating the passive range of movmemnt of the lower extremity measured immediately after the VSI protocol indicate higher values than the identical variables measured immediately (one minute) after the standard SSI protocol. At the same time, the results on the variables for evaluating the muscular function between the two protocols are manifested with minor differences. The T-test of paired samples evaluated the impact of only one bout (VSI protocol session - static stretching with additional vibration), on all dependent variables versus only one bout of SSI protocol session (non-vibration stretching exercise), on the same participants. The T-test showed that there were significant differences in the variables for the estimate of the passive range of movement of the lower limbs, compared to the mean values of the same variables measured after the application of the SSI protocol. Since all the results on the variables for the assessment of passive range of motion showed values less than the given criterion ($p < 0.05$), it is possible to state that the resulting difference is not a product of a random difference, but a systematic and deliberate influence of the treatment, in this case – vibration. On the variables for estimating the height of jumps and sprint running, the t-test did not establish the existence of significant differences between the two applied protocols ($p > 0.05$).

DISCUSSION

Before further discussion, it is important to note that this is one of the few studies in which the test protocol implied the measurement of the passive range of movement by the goniometric method, while determining the immediate effects of vibration exercise on the muscular function, thus comparing the effects of the previously conducted studies, to a certain extent it is difficult. However, several different studies have used the estimation of active or passive motion amplitude, immediately after applying a particular vibrational stimulation, in the various modalities. In the research (Cronin et al. 2007), authors determined significant changes in the active range of movement in the hip (90°), (knee extension test). Significant improvement of the active amplitude of the motion (before-after) was recorded in three of the four vibrational protocols (1.6-2.1%), and the highest average improvement (3.1° or 2.1%, $p = 0.007$) was recorded in the highest vibration frequency protocol ($f = 47$ Hz, $A = 5$ mm), but nothing more significant than the other applied protocols without application of vibration. If the results of their research (1.6-2.1%) are compared with the effects of our study (6.15%), there are large differences in the magnitude of the effects achieved. However, both studies have shown that Cronin and his colleagues used a hand-built vibration device for their research, which, unlike a commercially used device for our research, generates random vibration. Also, the authors of the aforementioned study used a locally (segmentally) applied device where no stretching exercises were performed, but the tested extremity was only in contact with the vibration device in a relaxed position. On the other hand, Sandsa et al. (2006), in contrast to the aforementioned study (Cronin et al., 2007), incorporated static stretching exercises with additional vibrational stimuli. Sands and colleagues wanted to determine the acute and chronic effects of locally applied vibration, applied in static stretching exercises, to improve the amplitude of the movement relative to the same stretching exercises without applying vibration. As in the earlier study, the results show that in the acute part of the study the range of movement of both extremities was significantly improved (p <0.05), in the group that performed static stretching exercises with additional vibration. However, the authors do not report the magnitude of the obtained effects, so it is difficult to compare their effects with the effects of this study. On the other hand, in the research (Dallas and Kirialanis, 2013), the authors had the task of identifying the acute effects of various body vibration training protocols on flexibility and jump performance in active gymnastics. The results demonstrate that both protocols are effective in improving flexibility, but with a slightly higher rate of improvement in WBVSS (whole body vibration static stretching). However, data from the second part of the study, which concerned the determination of the acute effects of vibrational training to improve muscle power properties, did not reveal a significant interaction between treatment for concentric and eccentric-concentric jumps. In a further discussion, relying on the results of earlier research, the authors cite several different mechanisms of physiological nature, possibly due to the acute improvement of the flexible properties. Among other things, circulatory, thermoregulatory and neural mechanisms are mentioned. Furthermore, in their discussion, authors point out that acutely applied vibration has a beneficial effect on flexibility, while the same stimulus on the power carries more sustained but aggravating effect. It has been previously known that exposure to vibrational training can lead to an increase in body temperature and thus to the improvement of muscle elasticity (Bosco et al., 1999; Issurin et al., 1994; Mester et al., 1999; Sands et al., 2006;). In a review article (Cochrane, 2011), in conjunction with the neural mechanisms of acute vibration, it discusses about several essential physiological mechanisms related to acute adaptation responses of vibrational training. Neural aspects, such as motor unit recruitment, muscular synchronization, muscular contraction, may represent primary mechanisms, possibly due to the acute improvement of flexible properties. Other mechanisms of acutely applied vibration, such as the effects of warming, when friction between vibrational tissues has the potential to induce body temperature increase of surrounding tissues (Issurin and Tenenbaum, 1999), in combination with improved local blood flow (Kerschan-Schindl et al. 2001), which ultimately can contribute to a significant acute improvement in nerve-muscle function. When it comes to a sprint variable, it is possible to point out that the results confirm what happened and on the variables for estimating the jump performance. Analyzing earlier studies of vibration in the form of whole body vibration training and its impact on sprint performance, it is important to note that although there are a number of papers dealing with the mentioned problem in chronic settings (Delcluse et al., 2005; Paradisis and Zacharogiannis, 2007). However, the number of papers related to the determination of the acute effects of indirectly applied whole body vibration on the improvement of sprinting abilities is still underdeveloped. One of the available studies, (Bullock et al., 2008), (although in its experimental design somewhat different from this study) reports identical results.For the purpose of their research, seven top athletes were selected, engaged in two test sessions conducted over two days, with the aim of identifying the acute effects of whole body vibration training on sprint and jumping performance. Results on sprint variables show that the control protocol has deteriorated by 0.06 seconds and 0.03 seconds in vibration. Split times also show identical results. It is a similar situation when it comes to the results for the jumps. Discussing the obtained results, the authors state that this was primarily one of the first studies to deal with the acute effects of whole body vibration training on the sprint performance of highly trained athletes. Discussing the neurological aspects of selected subjects, it is stated that well trained individuals from sports where is dominant sprint-speed have well developed muscle strength, optimized motor-neuronal excitability, high reflex sensitivity, and good recruitment of fast muscle units. The author's conclusion is that the vibrational stimulus in such loads was not a strong enough stimulant for higly trained sprint-speed athletes. Given the fact that during the run (sprint 15 meters) there were no significant differences in the applied protocols in our study, and since we also engaged well trained athletes, it is possible to agree with the above statement. When acute improvements are in progress, it is noteworthy that there is much less space available for well trained individuals for further improvements in the conditions of rapid manifestation of maximum muscular force, compared to poorly trained individuals. Accordingly, this knowledge may represent another significant factor that can significantly contribute to the appearance of different and sometimes opposit and even confusing results of the research carried out.

CONCLUSION

The results of this study indicate that the whole body vibration training applied in static stretching exercises effectively improves the range of movement of lower leg muscles, but not the muscular function measured by the types of vertical jump and maximum sprint test. This study demonstrates that the whole body vibration applied to the static stretching exercises does not produce significant acute improvement of the muscular function in comparaison to identical stretching exercises without vibration, and therefore should not be used in this way immediately before the power activity, unless the primary goal of the main part of the training is currently improving the joint range of movement.

LITERATURE

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Conflicts of interest. The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

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