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The Effects of Vibration Plate Training on Strength and Static Balance of Women Who Practise MaintenanceSports

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Abstract

The purpose of this study was to investigate the effects of a program of training on the vibration plate, simultaneous with a conventional program of strength, which consists of exercises that underlie the training of the knee flexors and extensors, and which ensures women's strength and postural balance. The conclusion of this study was that the side-alternating vibration have beneficial effects on the control of the static balance, for women in this category of age. The results of the isokinetic force were similar for both experimental groups.

Keywords: vibration, strength, static balance, women

2. Introduction

There are many studies that showed that whole body vibration (WBV) can have a positive influence on the minimization of risk factors that lead to falls and fractures, this being performed through the improvement of muscle strength and of body balance. Even though the effects which influence and vary the characteristics of vibration (frequency, amplitude and the training duration) are not, at the moment, very well known, as vibration were used for the improvement of the isometric force of the leg's extensors. Delecluse et al. [11] showed that WBV have the potential of inducing similarities to the earned strength at the level of the knee extensors for the previously untrained women through this type of training, as to those observed after the resistance training at moderate intensity. Verschueren et al. [31] showed that in 6 months, the training program based on vibration for women in post-menopause improved their isometric and dynamic muscle force by 15-16%. On the other hand, a relative number of studies received less positive results of the vibration training. It had been demonstrated that vibrations might have negative effects on the soft tissues which can quickly lead to fatigue muscles [1], to the decrease of contraction, of strength [6], and to the loss of receptor and of nerve conduction velocity [2]. Also, it had been demonstrated that 11 weeks of standard training with vibration do not appear to be a beneficial method for the increase of the maximum muscle force, of the rate development of force or of the increasing jump height for healthy young adults [12]. The vibrations were introduced as an intervention in the force training, because it can increase the unitary motor activity of the inferior limbs through an augmented exciting opening from the muscle receptors. When the "tonic vibration reflex" is evoked, it is believed to lead to a better activity of the motor neurons due to the increasing entry received from the afferent pathways [13, 28]. However, the results of the WBV test, respecting the level of activity during the exposure, broadly, are hard to specify due to the nonspecific propagation of the stimuli's vibration, from the foot level. What is more, the tonic vibration caught by the reflex has been demonstrated as a result of a concise exposure of the stimuli of high frequency, applied directly on the sinew which causes a transitory growth of the muscle activity [13] (see also Nordlund and Thortensson [21]).

Runge et al. [27] showed that 2 months of vibration treatment, for the elderly lead to the decrease of the lifting time from the chair, by a percent of 18%. Bogaerts et al. [5] showed that the WBV training might improve a possible answer from the toes. Iwamoto et al. [16] reported that, after 3 months of vibration training, the time on one foot and the stride length have increased notably, meanwhile the speed did not have any particular decrease for the elderly women. By contrast, for young volunteers (19-38 years) who are not athletics, Torvinen et al. [29] showed that there is no effect during the 4 months of WBV intervention on the static and dynamic body balance.

We consider that no other study examined in detail if WBV leads to an extensive stimulation of the receptor's paths, and later to a better activity of the muscles or if it can be held responsible for the improvement of the postural control and of the knee muscles.

In previous studies, has been confirmed that the specific training of the force might reduce the control of the posture and improve the balance for elderly people, modifying the manner in which CNS shapes the muscles answers [4]. However, the effects of a strength training program for elderly would definitely be beneficial, especially because of the low level. There is very little information regarding the adaptations of the balance and strength training to the middle-aged people, without any decrease of their daily physical activity; and even less to the females who practice random sports. For a better understanding of the effectiveness of the strength training on plate with alternating vibrations (SAV), we have decided to compare the effects of this one with the ones produced by a conventional treatment of strength formation, with the same results, being more specific the static balance and the knee muscle force, to the women aged between 27-35 years, who practise different sports for pleasure or for maintenance. Therefore, the purpose of this study was to investigate the effects of a SAV training program with the similar training program, without using a vibration upon the knee muscle force and the static balance to the females from this category of age**.**

3. Materials and Methods

2.1 Participants

The whole female participants were recruited from the testing and recovery clinic for KINISIS athletes from Bucharest. 42 women who practise sports but not performance ones were randomly dispersed into one of the three groups: a vibration group (GV, no.=16, age=27.5 ± 6.5 years, height=170.6 ± 5.8 cm, weight=63.8 ± 4.5 kg), a strength group (GS, no.=16, age=28.7 ± 4.8 years, height=166.22 ± 8 cm, weight=62.4 ± 7.6 kg), and a control group (GC, no.=10, age=27.2 ± 7.8 years, height=165.2 ± 7.9 cm, weight=63.4 ± 5.2 kg). Every one of them was a healthy volunteer, without any disorder in muscles or in bones, or a neurological one or a chronic disease. They never participated in a program of this type of training, in the 12 months before the study, and did not receive any medication which might affect their adaptation to strength. The participants signed a form in which they give their consent for the participation in the study, before being subjected to the experiment.

2.2 Training

Both experimental groups (GV and GS) have been training for about 16 weeks (48 training sessions, 3 sessions/week, at least one day of rest between sessions). Each training session has been divided into 3 stages:

a) warming-up (10 min. stretching and walking exercises)
b) main training stage (35 min., isometric and dynamic exercises)
c) recuperation stage (10 min., stretching)

During the main training stage, an interval of protocol exercises had been applied, alternating the muscle contractions with the time of resting (work: rest= 1: 2). The female participants performed, in each training session, 2 sets of the following exercises:

- semi-squats (knee angle: 120° and 90°),
- full squat (full bending),
- hack squat (with assistance)

- wide-stance squat (the distance between malleoli: 30-55 cm),
- semi-squats in one leg and lunge.

Most of the exercises had been completed with a weight excess (around 30% body weight). Each set continued with 2 isometric actions + 6-15 repetitions. The duration of each isometric action was about 10 sec. The fundamental idea applied was to alternate two types of action, isometric, as “before of tiredness”, and 6-15 concentric actions which depend on the time, type and level of the participant. The typical instruction was about 10s isometrics + 5s rest + 10s isometrics + 5s rest + 6-15 repetitions [10]. The duration of each set was about one minute. During the isometric action, the female participants were verbally encouraged to strongly contract their muscles, taking into account their level and their number of sessions. To increase progressively the volume and the intensity of the training, the type of exercises, the number of sets for each exercise and the rate between exercises as well as the time of rest, were modified. The GV (Vibration Group) has conducted the same exercises on the vibration device (Galileo, Novotec, Pforzheim, Germany). The characteristics of the vibration training varied according to the principle of progressive increase of the amount of workout (1^{st}-2^{nd} week: amplitude of 2-4 cm and frequency of 15-20 Hz, and 3^{rd}-16^{th} week: amplitude of 8-12.8 cm and frequency of 25 Hz). The training protocol was strictly supervised by 7 personal assistants.

2.3 Testing

2.3.1 Static Balance

For the evaluation of static balance, 3 tasks of high difficulty were conducted, while the participants were staying on a force platform, built with four embedded transducers with unique axis (The Square Plate Stabilometre, extracting frequencies of: 100Hz, 100x100 cm). These tasks had been selected especially for evaluating the dysfunctionality of balance, and for distinguishing the postural answers [3]:

1. **Normal Quiet Stance (NQS).** The female participants were asked to step on the force platform and to adopt a normal balance position. Afterwards, they were instructed on how to stay very motionless and to maintain their position. A normal support area was adopted (the width position was set at an inter-malleoli distance of about 10-15 cm), and the arms dangling freely on both sides of the body.
2. **Sharpened Tandem (ST).** The instruction for the female participants was that they had to step on the force platform and to position their heel of the non-dominant foot in front of the toe of the dominant foot, not leaving any space between the legs. The arms were fixed on the hips with their elbows bent at approximately 100°. Once the participant was fixed in the specific posture, the testing has begun.
3. **One-Legged Stance (OLS).** The participants had been instructed to stay on their dominant limb, while the nonsupport limb was bent at the level of the knee, with the plantar surface of the leg steadily on the knee of the supported leg.

The data began to be registered once the subject remained stable in the required position for 10s. For the accommodation with the required posture, the female participants benefited of a period of adaptation. The participants were instructed to look straight forward and to fix their sight on a mark (3 cm diameter) positioned at the level of the eyes at a distance of approximately 1.5 m. The 3 balance tasks were carried out at the same time of the day, before and after the training, for avoiding any chrono-biological effect, and the order of the presentation was counterbalanced for any other possible effects. The results of the force platform were transferred into an electric amplifier built with 8 channels (the yield of the radius action: +5V) with filters of the built up bridges (the answer of the frequency >7kHz), exemplifying digitally through a purchased board of data (Advantec PCI1716 A/D card, 100 Hz), and analyzed in real time using an analysis software made manually. The Anterior/Posterior (A/P) and Medial/Lateral (M/L) displacement (cm) of the Centre of Pressure (CoP), was determined by the Ground Control Forces (GCF). The CoP instant position (ay, ax) was calculated from GCF, based on the following equations:

$$a_x = {}^{1}\!/_{2}\ a_{zo} - (F_1 + {}^{F_2}\!/_{F_t}) \quad ; \quad a_y = {}^{1}\!/_{2}\ a_{zo} - \left(F_2 + {}^{F_3}\!/_{F_t}\right)$$

Where a_{zo} is the length of the surface plate. The postural balance was quantified, the amplitude top with top (CiPmax) and the standard deflection (CoPsd) of the CoP oscillations, together with the A/P and M/L axis. The two parameters are considered as the representatives of the CoP displacement, offering information regarding the stability limits of the body oscillations during the postural task and the total trajectory around the position of a median during an established duration [3, 4, 15].

2.3.2 Isokinetic Evaluation

The isokinetic force of the knee muscles extensors and flexors was evaluated by using a Cybex dynamometer (Cybex Norm, NY) The female participants were familiarized with the isokinetic dynamometer in a period of time over 1 week (with 3 sessions of 20 minutes). They were positioned and secured with straps in accordance with the Cybex manual (Cybex Multi-Joint System Manual). After a standardized warm up period, the participants carried out 3 maximum extensions and dumbbell curls of the knee, in 4 concentric velocities (60°, 120°, 180° si 240° $X\ S^{-1}$) and 2 eccentric (60°, 120° $X\ S^{-1}$) presented randomly. The movement started from 0° (full extension) up to 90°. A break of 2 minutes between the tests was permitted for the elimination of the tiredness effects. Since the registration moment, the trails of the angular position, Constant Angular Moment (CAM) at 55° (knee flexors) and 65° (knee extensors), were used further more for the analysis. Three tests were carried out in each angular velocity and the best one was selected, based on the moment of maximum yield.

2.3.3 Statistical Analysis

For all variables, 3 (Group) x 2 (Time), together with repeated time measurements were used for the examination of the differences between the groups, before and after the training. The interactions of significant Group x Time were analyzed by using the post-hoc Tukey test. The importance level was set at $p<0.05$.

4. Results

No female participant quit the study. At the end of the first week of training, two participants complained about the appearance of a sensation of weight at the knee level, having conjunction, probably, with the vibration training; but no secondary effects were reported.

3.1 Normal Quiet Stance (NQS)

The ANOVA results indicated an effect of the significant interaction (Time X Group) upon the CoPmax (F_2,35=3.71. $p<0.05$) and CoPsd (F_2,35=2.36. $p<0.05$) displacement in the A/P direction. The post-hoc analysis indicated that the A/P values of the CoP decreased significantly just after the vibration training. Moreover, the CoPmax and CoPsd values, after the training, were significantly lower ($p<0.01$) in VG in comparison with SG. Additionally, a significant interaction upon the M/L CoPmax (F_2, 35=3.01. $p<0.05$) and CoPsd (F_2,35=5.28. $p<0.01$) displacement, were found. Post-hoc analysis indicated that the M/P CoP values decreased significantly ($p<0.05$) just in the VG, but not in the SG and in the study. CoPmax and CoPsd values after the training were significantly lower ($p<0.01$) in the VG than in the SG.

3.2 Sharpened Tandem (ST)

During the ST test, ANOVA results indicated an effect of a significant interaction (Time X Group) upon the CoP in A/P (CoPmax: F_2, 35=5.49, $p<0.05$; CoPsd: F_2,35=6.9, $p<0.05$) and in M/L (CoPmax: F_2,35=14.47, $p<0.001$; CoPsd: F_2,35=5.04, $p<0.05$) direction. Post-hoc analysis indicated that the CoP values decreased significantly ($p<0.05$) just in the VG, and not in the SG and in control. CoPmax and CoPsd values after the training were significantly lower ($p<0.01$) in the VG than in the SG in both A/P and M/L axis.

3.3 One-Leg Stance (OLS)

During the OLS test, ANOVA results indicated an effect of a significant interaction (Time X Group) upon the CoP displacement in the A/P (CoPmax: F_2,35=10.75, $p<0.001$ and CoPsd: F_2,35=12.03, $p<0.001$) and M/L (CoPmax: F_2,35=18.38, $p<0.001$ and CoPsd: F_2,35=12.73, $p<0.001$) direction. Post-hoc analysis indicated that the CoP values decreased significantly just in the VG, and not in the SG and in controls.

3.4 Isokinetic Force

The results showed an effect of a significant interaction upon a concentric moment ($60° \cdot s^{-1}$: F_2,35=27.64, p<0.001; $120° \cdot s^{-1}$: F_2,35=19.10, p<0.001; and $180° \cdot s^{-1}$: F_2,35=5.24, p<0.05) and eccentric ($120° \cdot s^{-1}$: F_2,35=16.84, p<0.001; $60° \cdot s^{-1}$: F_2,35=9.66, p<0.001) of the knee extensors. Post-hoc analysis showed a significant increase for the VG (eccentric $120° \cdot s^{-1}$ and concentric 60°, 120° and $180° \cdot s^{-1}$) and for the SG (eccentric $60° \cdot s^{-1}$ and concentric 60° and $120° \cdot s^{-1}$) and not in the controls. Even so, after the training, there were noticed no significant differences between the experimental groups, at no tested angular velocity. Similarly, an effect of a significant interaction on the concentric moment was observed ($60° \cdot s^{-1}$: F_2,35=3.95, p<0.05) and eccentric ($60° \cdot s^{-1}$: F_2,35=13.82, p<0.001; $120° \cdot s^{-1}$: F_2,35=14.94, p<0.001) of the knee flexors. Post-hoc analysis showed a significant increase for the VG (eccentric 60° and $120° \cdot s^{-1}$) and for the SG (eccentric $120° \cdot s^{-1}$, concentric $60° \cdot s^{-1}$) but not for the controls. After the training, no significant differences between the experimental groups at no angular velocity were observed.

5. **Discussions**

This study showed that the force and vibration training programs had improved the force of the knee muscles. But, the main discovery was that sets of 2 minutes, 27 Hz, amplitude 7-14 mm had a beneficial effect on the physical performance, and led to an increase of the time of lifting from a chair of about 18% in old patients [27]. The improvement of the balance might be the result of an excessive stimulation of the kinesthetic paths, evocated by the vibration stimulus. Mechanical perturbations caused by the vibration, can stimulate the sensorial receptors in the joints, muscles and ligaments, which, instead, might activate the reflex receptors. Priplata et al. [22] showed that using the vibrations at the level of the interior soles might be efficient in the damage amelioration, related to age, in the balance control. Starting from a neurophysiologic perspective, the most popular speculations imply the specific activation of the mechanical receptors, superficial and deep encapsulated in the Pacinian corpuscular [32].

Similarly, Bogaerts et al. [5] considered that the improvement of the balance performance after vibration might be the result of an extensive sensory stimulation and a more efficient utilization of the kinesthetic receptive answer. It can be assumed that the movement of the stationary platform can cause excessive excitation at the level of the muscles axis, leading to an increase in sensorial information, which is very useful for static balance.

The vibration trainings had as a result a significant decrease of the CoP displacement, in both A/P and M/L directions. Interesting is the tendency for a bigger improvement in the M/L direction, in comparison with the A/P one (approximately 55% vs. 40%), noted in the most difficult tests of the sharpened tandem (ST) and of the one-legged stance (OLS). In particular, the type of alternating vibration can induce vertical displacements reciprocal on the left and right side of an axis, creating a flat, frontal disturbance [8]. The postural control in the M/L direction is realized by the hip's muscles, whereas, the ankle's muscles play a negligible role because of their limited moment of force capability [33]. Moreover, the M/L balance is a better predictor of the falling risk than the A/P balance, even for those individuals who do not have any recent antecedents of fallings [19]. However, this declaration is not sustained by any of our discoveries. Considering that, the enlargement of the force of the knee extensors and flexors due to the conventional force training, was not associated with an improvement of the balance control.

Isokinetic Force

Based on our results, significant improvements were observed after the training especially at the level of the force of the knee extensors for both experimental groups. Interesting is that no differences were found between the vibration training and the force conventional one, at no other tested angular velocities. So, it is questionable if the vibration might have an impact on the maximum isokinetic performance of the knee muscles. These results seem to be in compliance with a recent study done by Rees et al [23], whose results tried to show a significant improvement of the twisting and power of the knee articulation after 8 weeks of vibration training to the healthy old men. Even so, the author observed a clear increase of the ankle's plantar flexor force. The reason why the WBV training fails to improve the force of the knee muscles more than the conventional force training might have been the connection with the intensity stimuli of the training. From our point of view, no substantial increase of the activation of the knee musculature occurred when the force exercises were carried out on the vibration plate, to cause additional adaptations (anyhow, no EMG data was available during the training, in this study).

Some studies are not in the same line with our results. Delecluse et al. [11] showed that the explosive force increased significantly (7.6 + 4.3%) just in the WBV group, while it remained unchanged in the resistance training group. Roelants et al. [26] suggested that the gained force to the older women is mainly due to the vibration stimuli and not only to the discharge of the carried out exercises on the WBV platform. Even so, the exact mechanism with which the vibration might lead to improvements is still unknown. The vibration experiments applied to the sinew, show a decrease in the muscle activity [24, 28], and seem to be incompatible with others which show a higher EMG of the knee extensors during the WBV [11]. It is obvious that during the WBV, the knee flexors and extensors should be simultaneously exposed to the vibration stimuli, which can further more to increase the inhibitory effects of the vibration and to give a precise result for the muscle activity.

Limits and perspectives

Three postural tests of high difficulty have been used in the present study for the evaluation of the posture. The vibration adaptations were higher for the balance tests, and more complex. A critical duration of the 10s position was considered appropriate due to the difficulty of the one-legged/heel stance over a toe, for more than 10s. The results confirmed that the test was sufficient as to reveal the training effects of postural control. In this study, no EMG activity from the selected postural muscles were registered neither during the training nor during the testing. It should be noted, however, that our main objective was to evaluate the vibration and force training effects in the static balance in females aged around 27-35 years, this aspect of the posture control being mostly underestimated in the vibration studies. Furthermore, the vibration training effect on other muscle groups like those of the ankle, must be, also, considered into the future studies. These muscles are the closest situated to vibrations and extremely important for the balance control [4].

Eventually, the results of the current study should be looked at carefully as the long lasting effects of the vibrations upon the peripheral nerves are not yet well explored. There have been studies that showed induced injuries due to the vibrations, which might harm the peripheral nerves on a long period of time [18].

6. Conclusions

In conclusion, the force exercises during the vibration training can improve the static balance and the force of the knee extensors and flexors in women around 27-35 years old who practice maintenance sports. The improvement of the static balance control was described in the 3 tests of high difficulty used in this study, in addition to the improvement of force.

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Nutritional Habits of High School Students, Probiotic Dairy Products Consumption Frequency and Their Identification Statements

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Abstract

This research was carried out in order to determine information about the nutritional habbits, probiotic dairy product consumption frequency and the identifications of students in their high school years. A total of 374 students participated in the research which included 183 female students and 191 male students who were still continuing their education at the central high schools attached to Pendik/Kurtköy County of Istanbul. A screening model and questionnaire forms were used in the research as tools for data collection.

The average heights of female students who participated in the research was 164.89±6.14 cm, their average weight was 55.25±7.86 kg while in male students the average height was 172.64±7.99 cm and average weight was 63.91±11.14 kg. 23.6% of the students stated that they do in fact skip meals, while 46.0% said they do not, and 13.6% said that they sometimes skip meals. 78.3% of the students indicated that they consume probiotic food and 21% stated that they do not. 32.9% stated they do so upon recommendation while 30.7% of those who do not consume said they do not because they did not know about it.