O r i g i n a l a r t i c l e

# Effect of the vibration board on the strength of ankle dorsal and plantar flexor muscles: a preliminary randomized controlled study

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**Abstract.** Aim of this preliminary work is to study the effects of the vibration board on the strength of dorsal and plantar flexor muscles of the ankle through a randomized and controlled observation. Sixteen sedentary right-handed females, ranged from 20 to 30 years of age, were selected; they were not affected by previous ankle sprains and were divided into two randomized groups. The study group followed a vibration board training in the orthostatic position with a 60° flexion of the knee in order to direct its mechanical impulses to the inferior limbs. Each patient of the study group performed daily, for 2 weeks, 10 repetitions that lasted 1 minute each (25 hertz of frequency). The control group followed a training protocol including 10 daily sessions for 2 weeks. Each session included 3 series of 10 repetitions of flexi-extension of the foot versus an opposite resistance of an elastic band, 60 centimetres long, that was stretched till 100 cm. Both groups were tested before and after these training programmes by Biodex isokinetic dynamometer in order to quantify the strength of the plantar and dorsal flexor muscles of the dominant ankle. Peak torque, power and total work of the dorsal and plantar flexor muscles were assessed. A power test at an angular velocity of 60°/sec for five repetitions and a resistance test at an angular velocity of 180°/sec. for 20 repetitions were performed. After the final isokinetic test, the results were submitted to a statistic evaluation (T test of Student) in order to analyze any possible significant differences ($p < 0,05$) among the initial and final values before and after the treatment. The results of the study group compared to the control group showed a significant increase in the power of the dorsal flexor muscles at an angular velocity of 60°/sec and in the peak torque, power and total work of the plantar flexor muscles at an angular velocity of 60°/sec and 180°/sec. We conclude that the use of the vibration board causes a continuous proprioceptive stimulation which increases neuromuscular receptivity determining a prevailing reinforcement of the plantar flexor muscles of the ankle. (www.actabiomedica.it)

**Key words:** vibration board, strength, dorsal and plantar flexor muscles

## Introduction

In the last years new technologies and new techniques, such as the vibration board, have been introduced in rehabilitation programmes. Vibration board may be considered as a simulator of proprioceptors stimuli since it provokes sinusoidal vertical oscillations which are perceived by peripheral receptors and sent to a central level. These stimuli cause an indirect contraction of the musculo-skeletal system that depends on the previously activated receptors.

Some authors show that such vibrations constantly applied with different frequencies cause an enhancement in the proprioceptors and functionality of the neuro-muscular system (1).

Proprioceptivity is a concept that was introduced by Sherrington to indicate sensorial afferences which origin from particular structures named proprioceptors during the execution of movements. Proprioceptors are nervous endings located in muscles, tendons and articular structures. They provide retroactive information on movements. These endings perceive nervous impulses which are transmitted to the spinal cord and, through posterior cordons, to the brain, in order to assess specific functions (2).

There are two types of receptors regulating muscular contractions:

- neuromuscular bunches, distributed in the muscular bodies;
- tendinous Golgi apparatus, located in the tendons.

Neuromuscular bunches regulate the reflexes evocated by stretching. If a muscle is suddenly extended, the inside of neuromuscular bunch is stretched producing an immediate transmission of signals to the spinal cord. These signals stimulate the nervous cells controlling musculo-skeletal fibres located around the bunch; the sudden extension of muscles causes a contraction which is automatically in opposition to the stretching. This process minimizes the variations in muscle.

The Golgi apparatus regulates tendinous reflexes and reveals the amount of its tension sending information to the spinal cord and to the brain. These informations are used by nervous endings to precisely regulate muscular tension related to functional needs.

Different receptors located in articular structures, such as Ruffini and Pacini corpuscles, provide information on joint position and movements and the speed at which such modification occurs. The foot is a part of our body that is capable of providing a great number of proprioceptive information which derive from receptors located on the anterior part of the heel, around the head of the metatarsal bones, of the big toe, and in the lumbricalis muscles. Continuous variations in pressure can be perceived in different parts of sole, accompanied by the oscillation of the supporting limb and the rest of the body (3).

Aim of this work is to study the effects of the vibration board on the strength of dorsal and plantar flexor muscles of the ankle through a randomized and controlled observation.

## Materials and methods

Sixteen sedentary right-handed females ranged from 20 to 30 years of age were selected.

They were not affected by any previous ankle sprain. They were divided into two randomized groups.

The study group (8 patients) followed a vibration board training in the orthostatic position with a knee flexion of 60° in order to direct its mechanical impulses to the inferior limbs and to avoid the involvement of the head (Fig. 1). A Fitwave board with two motors producing continuous vertical vibrations was used.

Each patient of the study group for 2 weeks performed daily 10 repetitions that lasted 1 minute each (25 hertz of frequency). A one minute pause after each repetition enabled muscular recovery.

The control group (8 patients) followed a training programme including 10 daily sessions for 2

**Figure 1.** Proper position on the vibration board.


**Figure 2.** Isokinetic equipment and proper position on it.

weeks. Each session included 3 series of 10 repetitions of flexi-extension of the foot versus an opposite resistance of an elastic band (blu Theraband intermedium resistance) 60 cm long. During the exercise the band was stretched till 100 cm.

Both groups were tested before and after these training rehabilitation programmes by Biodex isokinetic dynamometer in order to quantify the strength of the plantar and dorsal flexor muscles of the dominant ankle.

The isokinetic test was performed in a sitting position with a knee fixed with a rigid band and an ankle lined up to the rotation axis of the machine (Fig. 2).

Before the test, five minute training on a cyclette and five sub maximal repetitions were performed in order to get familiar with the machine. After each repetition a two minute long pause was allowed to enhance muscular recovery.

Peak torque, total work and power of the dorsal and plantar flexor muscles in the dominant ankle were assessed. A power test at an angular velocity of 60°/sec. for five repetitions and a resistance test at an angular velocity of 180°/sec. for 20 repetitions were performed.

During the isokinetic test the plantar and dorsal flexion of the ankle was complete and the test was performed in concentric contraction for each movement.

After the final isokinetic evaluation, the results of the treatment of the groups were compared and were statistically assessed (T Student test) to analyze any possible significant differences ($p < 0,05$).

## Results

All the patients completed the defined training programme.

In the control and in the study group, the mean peak torque, power and total work of the dorsal flexor muscles (DFM in the table 1 and 2) at an angular velocity of 60°/sec. and 180°/sec., before and after the training programme, were the following as described in the table 1 and 2.

In the control and in the study group, the mean peak torque, power and total work of the plantar flexor muscles (PFM in table 3 and 4) at an angular velocity of 60°/sec. and 180°/sec., before and after the training programme, were the following as described in the table 3 and 4.

**Table 1.**

| | Control group | | | Study group | | |
|---|---|---|---|---|---|---|
| DFM 60°/sec. | Before training | After training | Increase | Before training | After training | Increase |
| Peak torque | 22,36 N/m | 30,77 N/m | 8,41 N/m | 27,32 N/m | 39,34 N/m | 12,02 N/m |
| Power | 12,81 N/m | 20,84 N/m | 8,03 N/m | 17,11 N/m | 23,55 N/m | 6,44 N/m |
| Total work | 61 N/m | 91,92 N/m | 30,92 N/m | 74,34 N/m | 98,6 N/m | 24,26 N/m |

**Table 2.**

| | Control group | | | Study group | | |
|---|---|---|---|---|---|---|
| DFM 180°/sec. | Before training | After training | Increase | Before training | After training | Increase |
| Peak torque | 14,96 N/m | 20,31 N/m | 5,35 N/m | 18,55 N/m | 24,57 N/m | 6,02 N/m |
| Power | 17,42 N/m | 27,09 N/m | 9,67 N/m | 18,55 N/m | 26,57 N/m | 8,02 N/m |
| Total work | 168,77 N/m | 255,34 N/m | 86,57 N/m | 201,05 N/m | 279,55 N/m | 78,50 N/m |

**Table 3.**

| | Control group | | | Study group | | |
|---|---|---|---|---|---|---|
| PFM 60°/sec. | Before training | After training | Increase | Before training | After training | Increase |
| Peak torque | 48 N/m | 62,57 N/m | 14,57 N/m | 53,67 N/m | 80,24 N/m | 26,57 N/m |
| Power | 26,77 N/m | 36,67 N/m | 9,9 N/m | 32,6 N/m | 52,12 N/m | 19,52 N/m |
| Total work | 126,41 N/m | 157,87 N/m | 31,46 N/m | 149,31 N/m | 223,09 N/m | 73,78 N/m |

**Table 4.**

| | Control group | | | Study group | | |
|---|---|---|---|---|---|---|
| PFM 180°/sec. | Before training | After training | Increase | Before training | After training | Increase |
| Peak torque | 25,26 N/m | 35 N/m | 9,74 N/m | 31,82 N/m | 51,41 N/m | 19,59 N/m |
| Power | 34,87 N/m | 51,02 N/m | 16,15 N/m | 36,94 N/m | 66,9 N/m | 29,96 N/m |
| Total work | 354,91 N/m | 478,11 N/m | 123,2 N/m | 355,6 N/m | 629,4 N/m | 273,8 N/m |

In the control and in the study group, the mean peak torque, power and total work of the dorsal flexor muscles and plantar flexor muscles at an angular velocity of 60°/sec. and 180°/sec., before and after the training programme, always increased.

The study group results, assessed before and after the training programme, compared to the control group showed a significant increase of the following parameters:

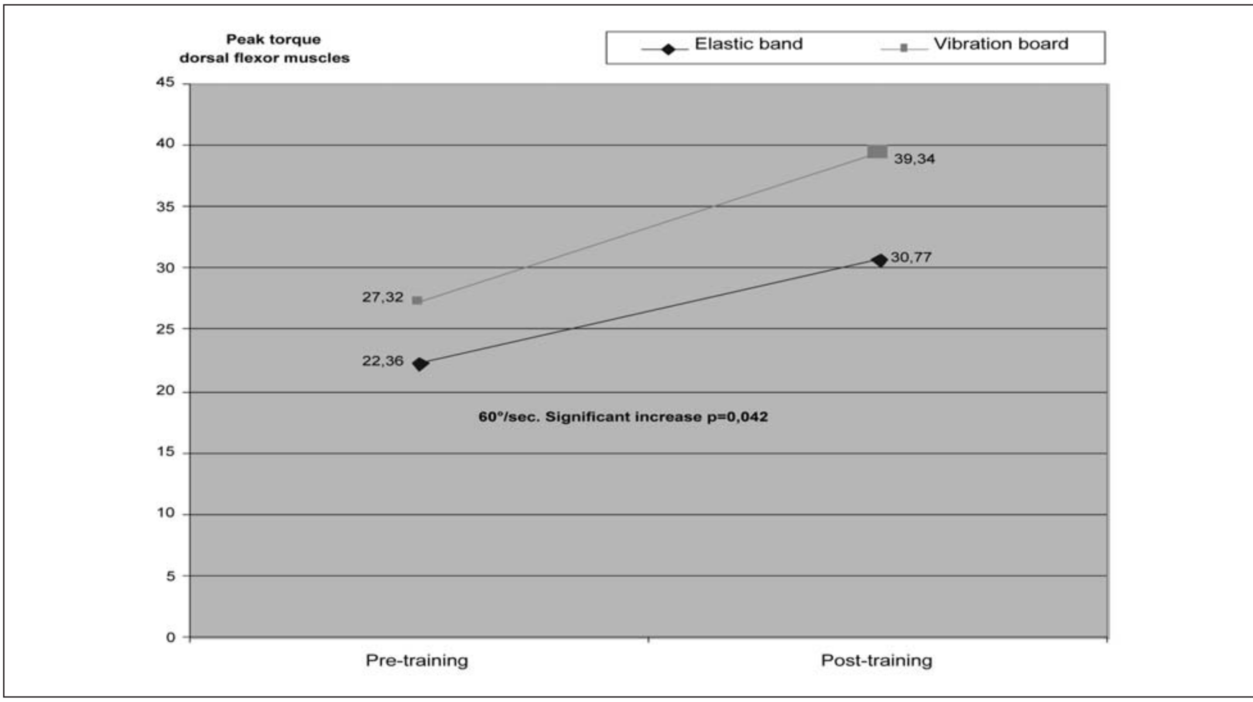
- power of the dorsal flexor muscles at an angular velocity of 60°/sec. (p=0,042) (Graphic 1)
- peak torque of the plantar flexor muscles at an angular velocity of 60°/sec. (p=0,032) and 180°/sec. (p=0,025) of angular velocity (Graphic 2)
- power of the plantar flexor muscles at an angular velocity of 60°/sec. (p=0,007) and 180°/sec. (p=0,02) of angular velocity (Graphic 3)
- total work of the plantar flexor muscles at an angular velocity of 60°/sec. (p=0,034) and 180°/sec. (p=0,027) of angular velocity (Graphic 4).

## Discussion

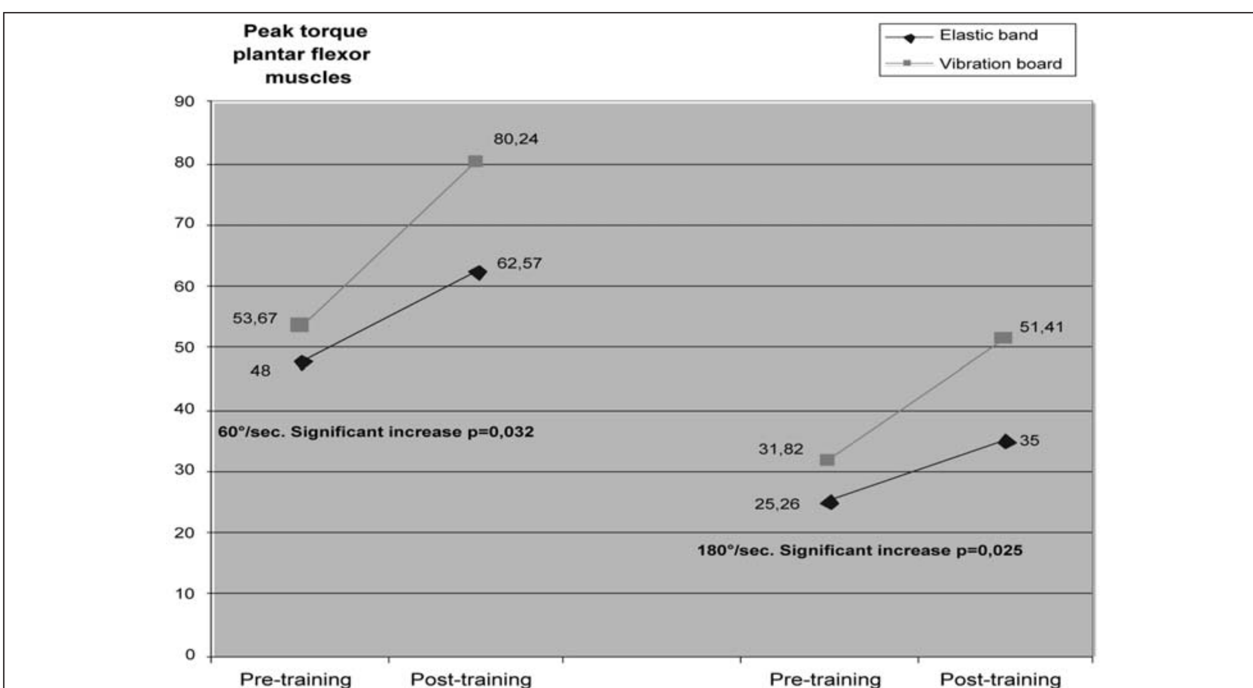
It has been demonstrated that vibration enhances proprioceptive capabilities and that their repetition increases the functionality of the muscle in producing strength (7).

Recent studies show a remarkable improvement in the flexibility of the vertebral column and of the flexor and extensor muscles of the leg and foot during vibration. Nevertheless the electric activity of these muscles is increased notably if compared to their normal electric activity (7, 8).

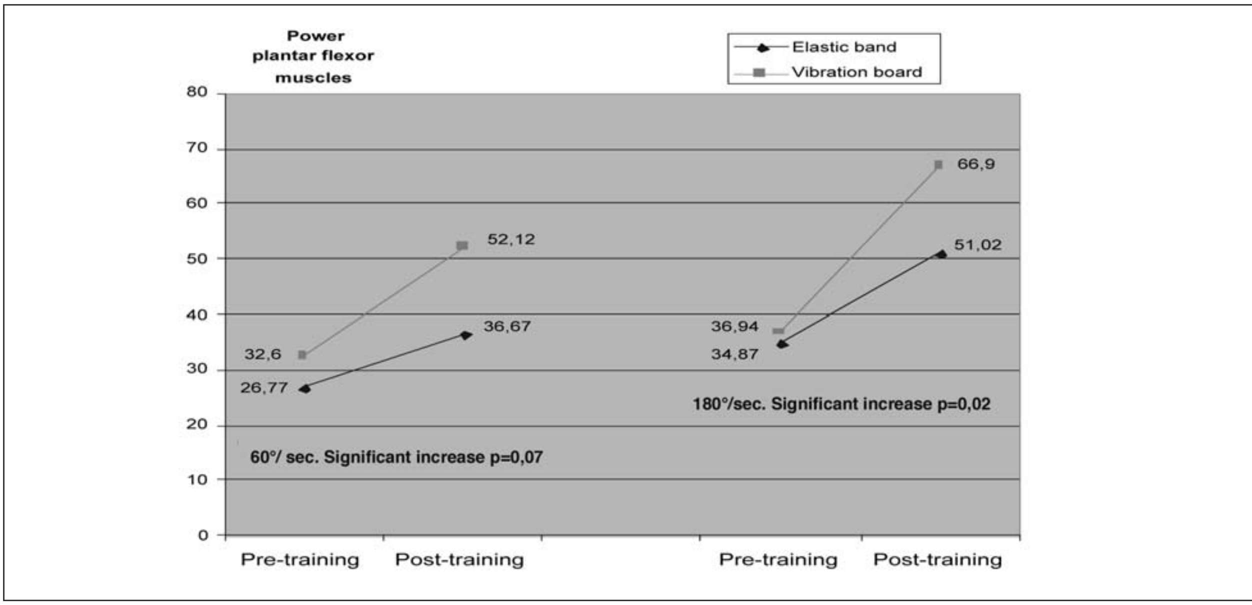
This increase enhances blood circulation and has positive effects on cartilage, bone, hormonal systems, and neurotransmitters (7). Further studies demonstrated the effects of vibration on muscles of the forearm and showed that a series of stimulations of 5 repetitions lasting 1 minute each, at a frequency of 30 hertz, with a minute pause, increases the strength and the power not only in the above mentioned muscles but also in other ones located nearby (8).



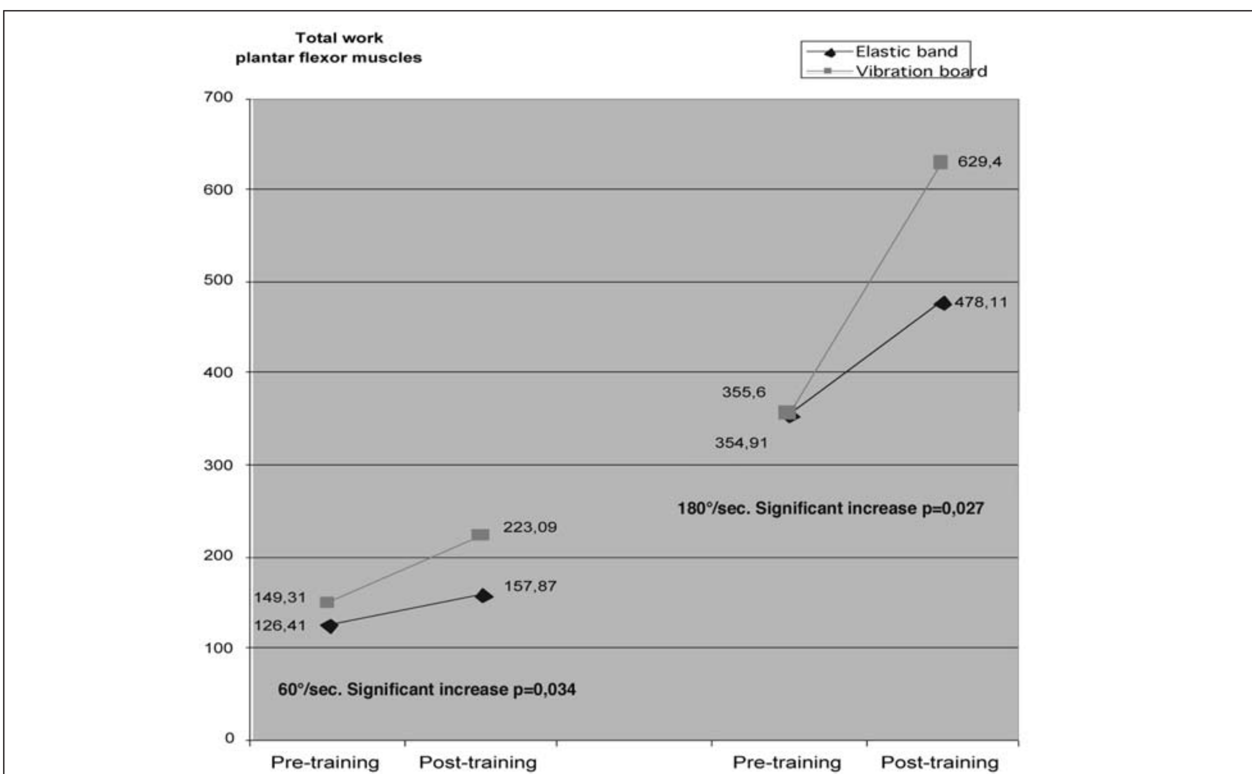

**Graphic 1.** Significant increase of the peak torque of the dorsal flexor muscles at an angular velocity of 60°/sec in the study group (vibration board) compared to control group (elastic band) before and after the training programme.




**Graphic 2.** Significant increase of the peak torque of the plantar flexor muscles at an angular velocity of 60°/sec and 180°/sec in the study group (vibration board) compared to control group (elastic band) before and after the training programme.




**Graphic 3.** Significant increase of the power of the plantar flexor muscles at an angular velocity of 60°/sec and 180°/sec in the study group (vibration board) compared to control group (elastic band) before and after the training programme.




**Graphic 4.** Significant increase of the total work of the plantar flexor muscles at an angular velocity of 60°/sec and 180°/sec in the study group (vibration board) compared to control group (elastic band) before and after the training programme.

Although initial isokinetic data were not homogeneous, since values related to peak torque, power, and total work in the control group were inferior to those of the study group, from the analysis of the results before and after these training programmes, it can be noted that in the study and control group all subjects showed increases of peak torque, power, and total work, both in power (60°/sec.) and resistance (180°/sec. ).

Therefore the study group, whose initial values of peak torque, power, and total work were higher, showed a greater difficulty in achieving significant percentage variations.

Nevertheless the comparison between the study and control group demonstrated significant variations of the peak torque of the plantar flexor muscles at an angular velocity of 60°/sec. ($p = 0,032$) and 180°/sec. ($p = 0.04$), of the power of the plantar flexor muscles at 60°/sec. ($p = 0,007$) and 180°/sec. ($p = 0,02$) and of the total work of the plantar flexor muscles at 60°/sec. ($p = 0,031$) and 180°/sec. ($p = 0,024$).

Furthermore a significant increase at an angular velocity of 60°/sec. was noticed only in the power of the dorsal flexor muscles ($p = 0,042$).

These results suggest that the vibration board causes a significant increase of peak torque, power, and total work in the plantar flexor muscles at an angular velocity of 60°/sec. and 180°/sec. and a significant increase in power of the dorsal flexor muscles only at an angular velocity of 60°/sec.

The improvement of all the parameters assessed by the isokinetic test (strength, power, and total work at different angular velocity) in the plantar flexor muscles in patients following a training programme with the vibration board is likely to be a consequence of the adopted position. With the knee flexed of 60° the stimulation through vibration provided a great number of stresses on the posterior muscles of the inferior limbs creating a positive influence on the plantar flexor muscles.

These results confirm the effective action of vibration board training and the efficacy of this machine in rehabilitation after inferior limb injuries.

## Conclusions

The use of the vibration board may increase the neuromuscular receptivity determining muscular reinforcement especially in the ankle plantar flexor muscles by provoking continuous proprioceptive stimulations.

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