EC ORTHOPAEDICS
Thesis

Flexibility Improvement through Work with Vibrations on the Whole Body: Acute Effects

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Abstract

Introduction: Mechanical vibrations are a training method that is on rise in these times providing benefits to different body systems.

Objectives: The present study seeks to observe the acute effects of a full body program with WBV on the capacity of flexibility in young adults.

Methods: 21 subjects from the general population, aged between 25 - 35 years, participated in this study voluntarily. They were randomly assigned to an experimental group (GE1: N = 7 or GE2: N = 7) or in a control group (GC: N = 7). All were a workout that consisted of 5 series of exercises of 45 seconds on a vibrating platform: the GE1 used F = 25 Hz and A = 2 mm, the GE2 used F = 45 Hz and A = 2 mm while the GC conducted exercises on the platform but without WBV. To assess the flexibility of hamstrings the AKE test was done before and after the intervention.

Results: The acute effects of WBV showed a significant increase in hamstring flexibility being observed in GE1 and GE2 greater gains in ADM compared to GC ($p < 0.05$). Such results lasted longer in GE1 y GE2 than in subjects who trained without VMC.

Conclusion: A short training program with WBV (25/45 Hz; 2 mm) improves hamstrings flexibility in young adults in the general population.

Keywords: *Mechanical Vibration; Flexibility; Training; Acute Effects*

Introduction

Mechanical vibrations

Based on the scientific contribution of the last 10 years, there are several reviews [1-4] and research articles [5-9] that deal with on experiments performed with a new training system that applies mechanical vibrations (VM) on a part or on the entire human body (VMC). Thus, it has been discovered that training with VM can have positive effects on the different structures and systems of the organism [3,10].

VMs are a type of training that is currently booming both within the field of high sports performance [2] and within health, for prevention and rehabilitation [4,6]. When used correctly, beneficial results are observed on muscles, bones, tendons and joints [3,4,10] and this has positive effects on force [11,12], flexibility [7,11-18], speed [19] and potency [16]. Therefore, many exercise specialists consider this new training method as one of the greatest advances in recent times in the development and optimization of different motor skills [2].

VMs can be generated on a specific place or on the whole body, the latter known as VMC. There are several devices designed for this but the most commonly used are the vibrating platforms (PV) emit VMC with a synchronous or vertical type oscillation, depending on the instrument used. In these platforms you can control some parameters of the vibratory stimulus such as: frequency (Hz), amplitude (mm) acceleration (ms^{-1}) and application time (s). Vertical oscillation PVs are designed to emit controlled three-dimensional vibrations throughout the body causing effects similar to conventional training with also controlled stretch-shortening cycles [4,20]. Because of the vibration, the muscle tissue modifies its length in a short period of time which triggers (due to its rapid stretching) the stimulation of the vibratory tonic reflex caused by reflex muscle stimulation [20].

This method produces a large volume of work that is not easily reproducible in other systems: keeping 30s a squat on the PV with a frequency of 30 Hz generates 900 muscle contractions [2]. The application of controlled vibrations generates an immediate increase in electromyographic activity (EMG), which can induce hormonal responses and generate structural changes in both bones and tendons and muscles [3].

When used correctly, the ease of use of the PV, the short time involved in completing a training session (10 minutes - 20 minutes) and the benefits that are observed presents them as one of the most tempting options of the market for complementary and/or alternative training to conventional sports [2].

Flexibility and mechanical vibrations

"Flexibility, limited to the field of sports provision [20], comes to represent, together with elasticity, one of the manifestations that is encompassed within the general concept of range of movement (ADM). All sports actions are characterized by having a certain ADM, which is conditioned by the articular path and the speed and/or acceleration generated" ([21], p. 24). The flexibility understood as a manifestation of the ADM is one of the most decisive motor skills in sports where large articular paths are required. Although it is manifested to a greater or lesser extent depending on the sport specialty that is practiced, it influences the performance of all motor gestures, so it is necessary to contemplate it within the planning of the training together with the strength and other motor skills during the sports performance optimization process [21].

A large part of the studies used by VMs to improve flexibility have been done in the field of sports training. In them there are positive results that show significant gains in terms of the flexibility of the hamstrings: Cochrane and Stannard [16] reveal improvements of 8.2% in the Sit and Reach test (SR); Cronin, Nash and Whatman (2007) observe improvements between 1.6 - 2.1% with a Dynamic ROM Test; Dipla., *et al*. [11] reveal a 13% improvement with the SR test; Issurin., *et al*. [12] observe that the subjects who used static stretching with VM improved 14.5 cm in the split versus 4.1 cm of those who did the conventional training without vibration; Jemni., *et al*. [18] in a study with highly trained gymnasts performing static stretching combined with VMC also show significant increases in forward split flexibility.

Despite the benefits shown in the sports environment, few publications have been used by VMs to study the impact on the general population on flexibility in search of improved mobility and autonomy [8,11,14]. The main objective of the present study was to assess the acute effects of a VM program on PV in improving ischiosural flexibility in a group of healthy young adults. If beneficial effects were observed, additionally, knowledge was provided on: 1) determining the existence or not of a VMC training program that is more effective, that is, where the vibratory parameters used for amplitude, frequency and duration generate greater gains in flexibility; 2) observe the latency of the adaptations generated with this training method.

Materials and Methods

Subjects

21 healthy young adult men from the general population aged between 25 - 35 years voluntarily participated in this study, presenting an average age of 28.71 (± 2.47) years. All subjects were previously assessed in the anthropometric parameters of weight and height

with which the body mass index (BMI) was calculated. The flexibility of the hamstrings was also evaluated by means of the "Active Knee Extension" (AKE) or "Popliteal Angle" test at rest (AKE0) and after the intervention was performed it was measured again (re-test). The inclusion criteria were: age between 25 - 35 years, male. It goes before, where it says that they are healthy subjects (they do not present diseases of any kind: cardiovascular, respiratory, neurological, muscular, abdominal or urinary) and sedentary (they did not perform regular daily workouts of any kind). The exclusion criteria: being highly trained subjects or elite athletes. All participants gave their written consent before the study began.

Materials

To carry out this study we used: an ergometric bicycle with a heart rate monitor (Athletic, 1800BVP, Brazil), a vibrating platform (Fitvibe, Pasweg6a 3740 Blizen, Belgium) that emits vertical vibrations, a photo camera (Canon, EOS 6D, Japan), a tripod (Vivitar®, VPT3662 62'', US) and a goniometer to perform the corresponding measurements. The data was analyzed using the statistical package PASW Statics 18 version 18.0.0.

Method

Preparation

They were randomly subdivided into 3 groups of 7 subjects each and randomly assigned a training program with specific characteristics. All of them had 5 stretching exercises of 45s duration each and with the same pause time (1: 1 work-recovery time ratio). Thus they were formed: the Control Group "GC" (N = 7) that performed the exercises on the platform but without mechanical stimulation; Experimental Group 1 "GE1" (N = 7) that conducted the training with 25 Hz and 2 mm amplitude; and Experimental Group 2 "GE2" (N = 7) that performed it with 45 Hz and 2 mm. For the registration of the images, some reference marks were placed on the stretcher to achieve a good framing of them, placing the camera in front of it and fixed on the tripod so that the subjects were focused on the center of the image with the 3 visible anatomical reference points (external malleolus, external femoral condyle and trochanter of the femur). AKE assessment was performed in degrees, using a goniometer that actively measured knee extension, with previously placed anatomical references.

Prior to the day of the study, a pilot test was carried out where all the people involved (experimental subjects and evaluators) became familiar with the protocol: the AKE test was performed to avoid the test effect, the quality of the instruments was calibrated and controlled (instrumentation bias) and the entire procedure to be performed on the day of the study was explained, to avoid possible errors of execution and/or measurement by any of the parties. Together with them the date on which the study would be carried out was fixed, it was scheduled to be in the morning and the first activity of the day. They committed themselves not to perform new training during the course of the investigation so that the results obtained would not be affected by external stimuli other than the VM.

Study day

All subjects slept at least 6 hours the night before and had breakfast that day as previously stipulated. Arrived at the site and to standardize the physiological conditions, they made a brief warm-up (10 minutes on an ergometric bicycle at 40 - 50% of the maximum speed controlled through the heart rate with the heart rate monitor). Then the first flexibility assessment of ischiosurals in a resting situation (AKE0) was carried out. At the end of the test, the corresponding treatment (intervention) was applied to each one. Thus, the GE1 performed the program with 25 Hz and 2 mm, the GE2 with 45 Hz and 2 mm and the GC performed the same but without mechanical vibration. At the end of the treatment, 4 instances of retest were performed (AKE1, AKE2, AKE3 and AKE4): 1 minute, 6 minutes, 11 minutes and 31 minutes after the intervention, with the aim of reassessing the flexibility of the hamstrings and Observe their behavior (latency) over time. All evaluation instances (pre-test, test and re-test) were given under the same external conditions (time of day, heat input, room temperature, etc).

Statistical analysis

Data collected from the study were analyzed using the statistical package PASW Statics 18 version 18.0.0 Copyright © 2009. The normality of the data was analyzed through Shapiro-Wilk. The differences between the statistical means of the groups were analyzed with a repeated measures ANOVA, with a post hoc analysis and Bonferroni adjustment. We worked with a 95% confidence level.

Results

Anthropometric measures. The subjects presented a mean weight of (78.82 ± 9.60 kg), a mean height of (1.75 ± 0.08 m), and a BMI of (25.67 ± 2.76 kg/m^2)

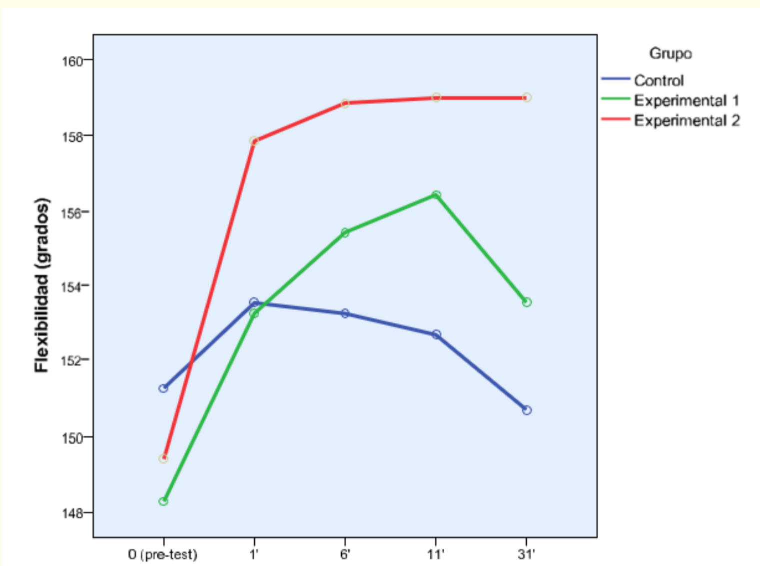
Flexibility of the hamstrings. The distribution of the data complied with the assumption of normality ($p > 0.05$). The means and standard deviations for each group (GC, GE1 and GE2) in each evaluation instance are presented in table 1.

Groups	Mean and SD		
Test	GC (s/v) n = 7	GE1 (25HZ) n = 7	GE2 (45HZ) n = 7
AKE0	151,29º ± 10,029	148,29º ± 10,452	149,43º ± 8,344
AKE1	153,57º ± 10,277	153,29º ± 9,304*	149,43º ± 8,344
AKE2	153,29º ± 10,161	155,43º ± 10,422***	158,86º ± 5,305
AKE3	152,71º ± 9,673	156,43º ± 11,473***	159,00º ± 5,260**
AKE4	150,71º ± 9,069	153,57º ± 10,706*	159,00º ± 7,000***

Table 1: *AKE flexibility test for each of the three groups.*

*References: SD: Standard Deviation; GC: Control group; GE1: Experimental Group 1; GE2: Experimental Group 2; AKE: Active Knee Extension Test; *: Significance (p < 0.05); **: Significance (p < 0.01); ***: Significance (p < 0.001).*

The acute effects of the VMC training showed a significant increase ($p < 0.01$) in the flexibility of the ischiosural musculature, with



Graph 1: *Behavior of flexibility for each of the three groups in each of the instances.*

greater gains in ADM compared to GC in GE1 and GE2. As can be seen in graph 1, the degrees achieved have a longer duration in time in the subjects of GE1 and GE2 than in those who trained without VM (GC).

Discussion and Conclusion

The acute effects of the VMC training showed a significant increase in the flexibility of the ischiosural musculature, consistent with what is observed in previous studies [11,16,18]. While in the GC (without VM) there were hardly any changes in flexibility with respect to the initial level of rest (+ 2.28º); in the GE2 (F = 45 Hz) the highest gains of the post-intervention ROM (+ 9.57º) were observed. Other studies also reveal significant gains using the same vibrational frequency: Cronin, Nash and Whatman [22] using an F = 45 Hz observed improvements between 1.6 - 2.1% with a dynamic ROM test; Issurin., *et al*. [12] using an F = 44 Hz combined with stretching exercises revealed gains in the Split of a 14.5 cm versus 4.1 cm compared to those who performed only conventional flexibility training. However, Cardinale and Lim [23] with the SR test observed with a group of sedentary women that using F = 40 Hz and A = 4 mm not only did not improve flexibility but even diminished it; while using F = 20 Hz and A = 4 mm with the same sample, improvements in flexibility were appreciated. In GE1 (F = 25 Hz) significant gains were also observed (+ 7.41º). Other research also shows positive effects on flexibility using similar vibratory parameters: Cochrane and Stannard [16] with an F = 26 Hz observed improvements of 8.2% in the SR test; Jemni., *et al*. [18] with an F = 30 Hz obtained very significant increases in the Split for both legs in the subjects who trained with VMC; Dipla., *et al*. [11] using an F = 25 Hz also revealed improvements of 13% in the SR test.

Regarding the latency of the gains obtained after training, a different behavior is observed according to the experimental group treated. While in the GC the few degrees earned are quickly lost after the intervention (in the 11-minute re-test they have already begun to decrease), the subjects who worked with VMC (GE1 and GE2) show a more stable behavior of the earnings earnd. Cronin, et al. [7] evaluate subjects again after 10 minutes of the intervention, while Chanou., *et al*. [15] perform the retest 15 minutes after the intervention and both studies observe also the same behavior over time. In GE2, the greatest gains were in AKE1 (1 minute post intervention) and continued to increase with small increases until AKE3 (11 minutes post intervention), which remained even in AKE4 (31 minutes post intervention). In the GE1 the increases were significant until the AKE3 retest (+7,41), in the next evaluation instance (AKE4) they are beginning to deteriorate (-2,13). Achievements achieved after the intervention with VM last longer over time when subjects combine flexibility training with VMC [15]. These changes could be attributed to the contribution of the vibratory tonic reflex to stretching that converts it into active tension.

From the data collected, it is verified that there is a training program with VMC that causes greater benefits in improving the flexibility of the selected sample. This program responds to certain specific VM parameters of F = 45 Hz, A = 2 mm and T = 45s (duration of each exercise with the same pause time). It is possible that using the same working methodology on a PV there are other parameters of VMC that also cause positive changes in the flexibility of the musculature involved in healthy young adult men of the general population as observed in the present study using F = 25 Hz.

The mechanisms responsible for causing such gains are not yet clearly identified. The VMs could enhance the spinal reflexes, inhibiting the antagonists and enhancing the agonist musculature thus achieving greater stretching. Other mechanisms that can influence the improvement of the extensibility of the involved musculature and ADM could be: the decrease in stiffness, increased blood flow and/or the increase in pain threshold [6].

Determining if there are other training parameters with VMC that are also beneficial and identifying the mechanisms that cause the gains are issues that could be considered in future research.

VMCs can be used with different training objectives in elite athletes for the optimization of sports performance [2]; considerably improve the flexibility of healthy people, youth and athletes [6]. The results of this study demonstrate that VMs are also an effective method to work with healthy young adults of the general population in the improvement of ADM, allowing them greater autonomy and a better quality of life [24-27].

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