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ABSTRACT

The purpose of this study was to examine the acute effect of Whole-Body Vibration combined with stretching (WBVS) on flexibility of shoulder’s joint in relation to bridge performance. Twelve artistic gymnasts that where dropped out from their competition duties (23,00 ± 2,29 years, 56,91 ± 6,23 kg, 164,08 ± 4,83 cm) composed the WBVS, and 12 female students of Department of Physical Education composed the control group (non vibration-stretching group: NVS) (20,33 ± 0,78, 58,91 ± 5,18 kg, 165,50 ± 4,01 cm). Both groups performed an 1-minute intervention program on a Whole Body Vibration platform that was turn on for WBVS, whereas NVG performed the same intervention program with the device was turn off. The total sample was assessed on bridge performance. Vibration (30Hz, 2mm displacement) was applied to two sites, four times for 10 seconds, with 10 sec of rest between times and one minute rest between sites. According to the results both groups improved “bridge performance” after the end of intervention program and remain this improvement for at least 60 minutes. Whoever, WBVS had significant increase flexibility than NVS. Conclusively, Whole-Body Vibration combined with stretching on shoulders joint may greatly influence flexibility in bridge performance.

KEY WORDS: Artistic gymnastics, range of motion, shoulders, shoulder flexibility.
INTRODUCTION

Artistic gymnastics is a sport that uses large ranges of motion (ROM) in various joints of body to achieve perfect postures and positions to fulfill the technical requirements-criteria of these exercises. Stretching, as the most popular of enhancing flexibility (3), is used by gymnasts as part of a warm up or at the end of each training session, mainly to improve or preserve joints flexibility. However, according to Stone and his colleagues, this acute stretching can cause a loss of maximum strength, rate of force development, and explosive performance (28). Flexibility in simple words means the range of motion in a joint or a related series of joints (22), and is categorized as both passive and active (18, 28). Passive flexible is distinguished by achieving a large range of motion without active muscles tension, whereas active flexibility is demonstrated when the gymnast achieves a large range of motion position by muscles tension moving the limb into position against muscle tension and/ or gravity, e.g “bridge” a movement/position in artistic gymnastics that consists a basic skill of gymnasts to perform more complex skills in floor exercises and in balance beam routines. So, enhancing ROM for this position would be advantageous to gymnastics performance. On the contrary, WBV is a new method that would allow flexibility enhancement, while enhancing or at least not limiting explosiveness would be quite applicable.

Whole body vibration (WBV) is a neuromuscular training method using an oscillating platform, upon which exercises are performed. This platform was originally developed well to improve muscle function in young (8, 9, 13). A single vibration bout has been shown to result on acute, but temporary, effects when it comes to muscle power and /or strength of lower limbs (4, 5) and arm flexors (5, 15). The most commonly explanation of neuromuscular activation is the Tonic Vibration Reflex (TVR) (20). This is the sustained contraction of a muscle due to the effect of vibration that activates muscle spindles, which are muscle receptors sensitive to stretch in the muscle. Afferent fibers send a signal to the spinal cord from the muscles spindles activating a reflex which causes the muscle to contract. The TVR also causes an increase in recruitment and synchronization of motor units within the muscle.

Enhancement of athlete’s flexibility as a result of vibration training has been shown in both short-term and long-term studies (Issurin et al 14). A lot of studies are referred on the effect of vibration to increase their range of motion rapidly and relatively painless in athletes of various sports, as synchronized swimming (25) figure skating (24), and gymnastics (26, 27, 17). Further, previous data suggests that WBV results in temporary increases in joint range of motion (7, 27, 29). In addition, Atha and Wheatley (1) and McNeal and Sands 18 point out the use of local vibration as a modality for
increasing ROM. However, other studies that combined stretching during vibration showed a promising means of enhancing flexibility (6, 14, 17, 22, 27). In WBV training, the subjects stands on a platform that generates vertical sinusoidal vibration at a frequency between 30 and 40 Hz. The mechanical action of vibration mediates fast and short changes in the length of the muscle-tendon complex. This may induce a non-voluntary muscular contraction termed the “tonic vibration reflex” (TVR), which is believed to depend upon the excitation of the primary muscle spindle (Ia) fibers (10, 12, 19).

The present study was focused to examine the acute effect of vibration with associated stretching on shoulder’s flexibility in relation to bridge performance. High level gymnasts that had dropped out from competition duties-regime, and who accumulated many years of experience with static stretching were participated in this study in order to investigate whether the use of vibration would be applicable to this category of athletes. Previous results has shown that WBV has an acute effect on joint’s flexibility where the practiced skill considered as examined skill (7, 11, 16, 17, 27). A lot of studies referred to the acute or long term effect via whole body vibration (2, 11, 29), or local vibration (14, 27). Further, vibration associated with stretching has appositive effect in ROM (14, 27, 29). In the present study a differentiation of this regime has attempted to investigate the effect of shoulders’ joint enhancement on bridge performance. For example, a bridge performance requires a great range of motion on shoulders’ joint and on the pelvic in vertebral column. It is not well known if vibration with associated stretching on shoulders joint affects bridge performance. So, the purpose of this study was to examine the acute effects of simultaneous stretching and vibration on shoulders’ flexibility as measured by bridge performance and have dropped out from training and competitive duties for many years.

**METHOD**

**Subjects**

Twelve artistic gymnasts (eleven female and one male) (age = 23.00 ± 2.29 years, height = 164.08 ± 4.83 cm, body mass = 56.91 ± 6.23) that were members of National team of Greek Gymnastics Federation and have dropped out of their training and competitive duties previous years, volunteered to participate in this study. Further, twelve female students of Department of Physical Education were participate and serves as control group with a mean age of 20,33 ± 0,78 years, body mass = 58,91 ± 5,18 kg, and body height = 165,50 ± 4,01 cm.
Equipment - WBV training

The vibration apparatus was a Power-Plate Pro 5 Airdaptive (Power-Plate North America, Northbook, IL.). The vibration device platform is approximately 54 cm * 77 cm * 32 cm with a total mass of 158 kg. The vibrations were set at the lowest displacement setting (2 mm) with a 30-Hz vibration frequency. The 30-Hz frequency was chosen as a part of the range of frequencies that cause inhibitory effects on the monosynaptic stretch reflex. These characteristics resulted in a peak acceleration of 3.62 g with a root mean square (RMS) of 2.56 g. The frequency and displacement were confirmed by placing a magnetic motion sensor on the top surface of the upper section of the vibration device (Liberty™, Polhemus, Inc., Colchester, VT, USA).

Testing Procedure

All participants, that were able to achieve the experimental skill, performed a five-minute warm-up consisting of callisthenic exercises, walking, and light stretching. Following this preparation, the gymnasts had their chronological age, body height and body mass recorded. A 1-cm thin gymnastics mat was placed on the floor under the gymnast to perform the testing exercise (bridge). Then all gymnasts were initially examined in the “bridge performance” (Figure 1).

Figure 1: An example of bridge performance.
From supine position gymnasts support his/her hands near to the neck and hyperextend the body simultaneously with straightness the hands and the feet (final position). A meter stick was used to measure the horizontal distance between hells and the nearest end of hand (wrist) to the hells (Figure 1). Participants then rested for 5 minutes before beginning the WBV exposure. Following the vibration session the participants in both groups, were retested for acute effects in the “bridge position” immediately after vibration stimulus and again at 30 and 60 minutes post-vibration. After the gymnast adopted the final position (test position) and descended to the limit of his/her self-selected level of discomfort for 3-5 seconds, a measurement was taken of the prescribed horizontal distance. The smaller the horizontal distance in bridge position the better the performance of this gymnastics skill. Three trials were performed and the best trial was recorded for further analysis.

Vibration session Procedures

After the initial test (pre-test) gymnasts were instructed to perform shoulder flexibility’s exercise on the vibration device. From seating position with bent knees, the gymnast placed his/her hands behind the torso (body) on vibration device and raised his/her hips from the floor, as removed them towards to the feet to the point of discomfort (Figure 2).

Figure 2: Experimental position of subjects for shoulder’s flexibility.
The protocol consisted of each gymnast stretching to the point of discomfort for 10 seconds followed by 5 sec of rest. This was repeated four times to result in 1 minute for complete stretching session. The same regime was repeated once again resulting in a two-minutes stretching session. Gymnasts rested in a seated position for 1 minute between vibrations tests. WBVS gymnasts stretched with the vibration device turned on, whereas the NVG performed the same stretching with the vibration device turned off.

**Statistical analysis**

The effect of the WBV on shoulders flexibility in “bridge performance” was analyzed by means of MANOVA for repeated measures {2 (group) *4 (time)} and multiple ANOVA’s analysis. The significant level for the tests was set at p< 0.05 and the data was presented as mean ±SD. All analyses were executed using the statistical package PASW 18.

**RESULTS**

The interaction effect between experimental condition (Experimental group vs control group) and time (pre, post 1, post 30, post 60), with respect to the bridge performance (depended variable) was examined with a 2*4 MANOVA. No significant interaction effect was found (Λ = .758, F = 2.13, p= .128) and no significant main effect for the experimental condition (F = 2.381, p = .137). The time effect however was significant (Λ = .211, F = 24.956, p= .000) and the post hoc repeated measures ANOVA revealed significant differences between pre and post1 measurements (F = 66.573, p = .000). No significant differences were found between a) post 1 and post 30 (F = .143, p = .709) and b) post 30 and post 60 (F = .009, p = .926).

An improvement in bridge performance in both groups was revealed between pre and post 1 measurement. Also, an additional improvement was observed in WBVS group 30 minutes after the end of intervention program and the mean value 60 minutes after was better from those of post test immediately after the end of intervention program as well. Descriptive characteristics of bridge performance in all measurements in both groups are presented in table 1.
Table 1. Means and standards deviations in all measurements of both groups (cm).

<table>
<thead>
<tr>
<th></th>
<th>Pre test</th>
<th>Post test 1</th>
<th>Post test 30</th>
<th>Post test 60</th>
</tr>
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<tbody>
<tr>
<td>WBVS (n = 12)</td>
<td>89.59 ± 7.99</td>
<td>83.83 ± 8.32</td>
<td>82.92 ± 10.97</td>
<td>83.50 ± 10.37</td>
</tr>
<tr>
<td>NVG (n = 12)</td>
<td>93.58 ± 10.35</td>
<td>89.42 ± 8.86</td>
<td>90.92 ± 9.21</td>
<td>90.50 ± 13.65</td>
</tr>
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Whoever, the percentage improvements was differentiated in two groups (Figure 3). It is mentioned that a negative effect was appeared in NVG between Post tests measurements.

Figure 3: Percentage improvement of groups in relation to bridge performance.

DISCUSSION

This study was undertaken to investigate the effect of low-frequency vibration with associated stretching on shoulders’ flexibility in relation to bridge performance in artistic gymnasts that have dropped out. The participants were selected to determine whether the influence of vibration and stretching could be demonstrated with this type of artistic gymnasts. This study also attempted a more powerful design by relating these tests with bridge exercise that consist a basic motor skill of flexibility in artistic gymnastics. In the present study high level artistic gymnasts were selected to determine whether Whole-Body Vibration combined with stretching could
enhance range of motion (ROM) in subjects who were accustomed to intense flexibility training and had participated in static stretching for a long time during their competitive career before this investigation.

According to the results both groups improved their “bridge performance” that means appositive effect of intervention program was revealed on shoulder’s flexibility. Whoever, the percentage improvement of WBVS doubled in relation to NVG. WBVS revealed an improvement of 7.45% thirty minutes after the end of vibration program whereas the corresponding improvement of NVG was 2.87%. It is mentioned that both groups remained the initial level of bridge performance 60 minutes after the end of intervention program, although the WBVS revealed an improvement by 6.78% compared to those of NVG (3.31%).

No many research efforts have been directed at the influence Whole-Body Vibration combined with stretching on flexibility enhancement. Results of the present study are in accordance with results of Atha & Wheatly (1) and Issurin et al (14) which stated that the influence of a 44Hz frequency with a displacement’s range of 0.1-0.3 mm resulted in similar improvement in ROM of the hip and low back as static stretching. Further, our results are in congruence with those of Sands et al (27) that underling a significant improvement in lower limbs flexibility with vibration in conjunction with static stretch. The authors proposed that vibration can be a promising means of increasing ROM beyond that obtained with static stretching in highly trained male gymnasts. In addition the findings of our study are in accordance with previous results (7, 21), which state that vibration enhances the stretch reflex loop through the activation of the primary endings of the muscle spindles, which influences agonist muscle contraction while antagonists are simultaneously inhibited (21). The benefits of vibration for stretching may be explained by different mechanisms, as reduction of phasic and static stretch reflexes, increase in pain threshold, increase in blood flow with a commensurate increase in temperature, and induced relaxation of the stretched muscle (14, 29). In addition, according to Rothmuller & Cafarelli (21), vibration enhances the stretch reflex loop through the activation of the primary endings of the muscle spindle, which influences agonist muscle contraction while antagonists are simultaneously inhibited. The enhanced flexibility measure following WBV was greater that that after the control and cycling interventions of the antagonist muscle. This in turn may have caused changes to intramuscular coordination to decrease the braking force around the hip and lower back joints and potentiate the sit and reach score (6). Further, possible mechanisms by which vibration and stretching affect flexibility may include decreased musculotendinous stiffness, muscular antagonist inhibition, and increased pain threshold (1, 29).
CONCLUSIONS

The results of present study revealed the effectiveness of vibration combined with stretching to improve flexibility. Further, vibration with associated stretching is more effective that static stretching. It may possible that WBV may be a viable alternative for increasing gymnasts’ flexibility and may be providing a viable alternative to standard types of flexibility training.

Practical applications

The importance of this study supported on the base that Whole-Body Vibration combined with stretching would be apply in gymnastics activities to enhance more effective flexibility in this sport.

Recommendations

The use of WBV as a tool for improving flexibility remains an exciting area for further investigation. Much research is still needed on the optimal frequencies, amplitudes and stimulation durations to improve flexibility of human’s joints. In a future research, a modification of the stretch-vibration protocol to longer than 10 sec may cause activation of other gains in flexibility. In addition, a future study may involve vibration on pelvic area and/or vibration-stretching by a different position on shoulder’s flexibility.

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