Journal of Physical Education and Sport ® (JPES), 13(4), Art 81, pp. 517 - 521., 2013
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

The effect of four-week interrupted intervention Whole-Body Vibration program on hamstring's flexibility

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Published online: December 25, 2013
(Accepted for publication November 15, 2013)

DOI:**10.7752/jpes.2013.04081;**

Abstract:
Flexibility is an essential part of training program on various sports and have been supported that increase performance and reduce the risk of injuries. Various methods have been applied with differentiated results upon the effect of different methods of stretching. The purpose of this study was to examine the effect of different method of stretching on hamstring's flexibility. Twenty six subjects separated in experimental group (WBV combined with stretching) that consisted by 12 artistic gymnasts and control group (Non Vibration Group: static stretching) that consisted by 14 track and field athletes. Both groups involved in a 4 weeks intervention program that was stopped after the end of second week, for two weeks, and restart for other 2 weeks of training. Subjects of WBV stretching group were exposed to a vibration treatment on the Power Plate vibration platform (30 Hz, 2mm) for 10 seconds by 5 seconds of rest four times to result in 1 minute of total stretching. According to the results both stretching methods had a positive effect on hamstring's flexibility. Further, cessation of training has a negative effect on hamstring's flexibility but this decrease disappeared with commence of training.
Key words: Flexibility, whole body vibration, stretching, maintenance.

Introduction

Various sports such as artistic gymnastics (AG), rhythmic gymnastics (RG), diving, judo, and others rely on the athlete's ability to achieve certain techniques and safely performance of skills. Stretching is used to improve flexibility about a joint in an attempt to promote better performance (Shellock & Prentice, 1985) and/or reduce the risk of injury (Safran et al, 1989). A common term that describes athlete's flexibility is the range of motion (ROM) in each joint (Sands, 2002). This parameter is an important component in sport performance especially on gymnasts that characterized by their ability to achieve limp position that are beyond the norm (Sands et al, 2006). Flexibility is categorized as both passive and active (McNeal & Sands, 2006; Sands & McNeal 2000). Both of them have an application in AG. Passive flexibility by achieving a large range of motion without active muscle tension (Magnusson et al, 1996) such as a split position or a pike position or attains a stretch position via gravity or inertia. Active flexibility is demonstrated when gymnast achieve a large range of motion position by muscle tension moving the limb into position against muscle tension and/ or gravity such as the end position of non support limb after a walk over.

On the other hand, gymnasts have been trained for a long period with static stretching (SS). SS is a traditional-common method that used by gymnasts during training in warm-up or at the end of training to improve the range of motion (ROM) in various joints and achieve special positions during performance. In this logic gymnasts pose a great ROM in main joints to fulfill the requirements for the sport of gymnastics. The same regime is applied by athletes in other sports such as track and field, trampoline and others. On the contrary, in cases where gymnasts or athletes must interrupt their training for a period of time a loss of flexibility could be appeared (Dastmenash & van den Tillaar, 2010; Depino et al, 2000).

Several studies have examined various stretching techniques to determine which stretching technique is most effective to enhance joint's ROM (Dastemenash & can den Tillaar, 2010; Meroni et al, 2010; Perrier et al, 2011; Funk et al, 2003; Williford & Smith, 1985). Further, recent studies dealing with the use of vibration as part of warm-up has indicated that ROM can be improved (Kinser et al 2008; Sands et al, 2006; Sands et al. 2008). Additionally, a common practice that has been reported to deter muscle injury is gymnast's participation with flexibility exercises during warm-up (Woods et al, 2007). Therefore, the purpose of this study was to examine the effect two different training protocols of four weeks interrupted intervention program of different method of stretching upon the hamstring's flexibility (WBV combined with stretching vs SS) on highly trained athletes that were participated for a long period on their competitive duties.

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Method

Subjects

A total sample of twenty eight subjects, males and females, free of injuries volunteered to participate in this study (age: 21.31±2.05 years, body mass: 68.42±11.95 Kg, height: 170.96±10.27 cm). All subjects were healthy and participated in physical activities 3-4 times per week and had no previous experience in WBV. Subjects separated in experimental group (WBV) that consisted by 14 artistic gymnasts (age: 20.50±1.78 years, body mass: 64.00±0.53 Kg, height: 165.25±7.45 cm) and control group (NVG) that consisted by 14 track and field athletes (age: 22.00±2.07 years, body mass: 72.21±12.13 Kg, height: 175.85±10.00 cm). However, two participants from the WBV group withdrew from the study due to personal reasons

Procedure

WBV group gymnasts stretched with the vibration device turn-on, whereas athletes in NVG performed the same stretching protocol with the vibration device turned off. The subjects on the WBV group were exposed to a vibration treatment on the Power Plate vibration platform with a frequency of 30 Hz and approximate amplitude of 2mm (Sands, 2006). A 30-Hz frequency is part of a range of frequencies that cause inhibitory effects on monosynaptic stretch reflexes (Turnbull et al, 1981). The protocol consisted of each subject stretching to the point of discomfort for 10 seconds by 5 seconds of rest. During practice each subject upon the device from stand position flexes his/her body to the lower limbs with cross hands to stretch hamstring muscles. The rest positions involved rising their body on the stand relax position. This was repeated four times to result in 1 minute of total stretching. Total subjects were participated in a 4 weeks intervention program that was stopped after the end of second week, for two weeks, and start again for the same time of period. During training period subjects practiced three times per week, day by day, and the same regime was followed after the cessation period for the next two weeks. A total of 12 sessions was performed by each subject during the intervention program.

Flexibility

Flexibility was measured before (pre test), immediately after (post test 1 min), 15 (post test 15 min) and 30 minutes (post test 30 min) after the end of intervention program. The test was always performed on the same day. To avoid diurnal variation, all testing sessions were conducted at the same time of day (16:00 to 19:00). Verbal encouragement was given throughout testing trials. The test was performed before the training period started (pre test), after the end of second week, at the start of 5th week and after the end of sixth week. No warm-up performed before the protocol and performance test. Flexibility was measured with the sit and reach test using a flex-tester box (Cranlea, UK). Subjects were instructed to flex their body-torso forward slowly as far as possible, without bending their knees and remain at the end position for 2 seconds (Fagnani et al, 2006). Two trials were performed, with a rest of 10 seconds, and the best was record and used for further statistical analysis.

Statistical analysis

Five separate 2-way (2^x4) ANOVA (group: WBV vs NVG * test occasion: pretest, post test 1 min, post test 15 min, post test 30 min) was used to examine the interaction effect between group (VG vs NVG) and time with respect to sit and reach (S&R) **a)** immediately after (1 min), 15 min and 30 min after the end of intervention program of 1est session, 6^{th} (post 6: 1 min, post 6 :15 min, post 6: 30 min), 7^{th} (post 7: 1 min, post 7: 15 min, post 7: 30 min), and 12^{th} session (post 12: 1 min, post 12: 15 min, post 12: 30 min) and **b)** to examine the interaction effect between group (VG vs NVG) and time with respect to S&R in the total duration of experimental design. The PASW v.18 was used to test the above hypothesis (Norussis, 1993) and the t-parameter estimates examined the differences between groups across the four separate measurements. The level of significance was set at $p < 0.05$. All values are presented as means ±SD. Percent changes in all examined variables from base-line following WBV exercise were calculated.

Results

No significant interaction effect between group and time was found with respect to flexibility test during the total duration of experimental design (F= .355, p= .786). The repeated measures ANOVA revealed significant differences with respect to time (F=12.452, p=.000). The differences were significant between pre 1 vs post 6 1min (F=35.861, p=.000), post 6 1min vs pre 7 (F=4.671, p=.041), and pre 7 vs post 12 1min (F=7.082, p=.014). Inspection of mean scores revealed that the means S & R score at pre 1 was significantly lower compared to mean scores at post 6 1 min, the means S & R score at post 6 1min was significantly higher compared to mean scores at pre 7 and the means score S & R at pre 7 was significant lower compared to mean score at post 12 1 min (figure 1).

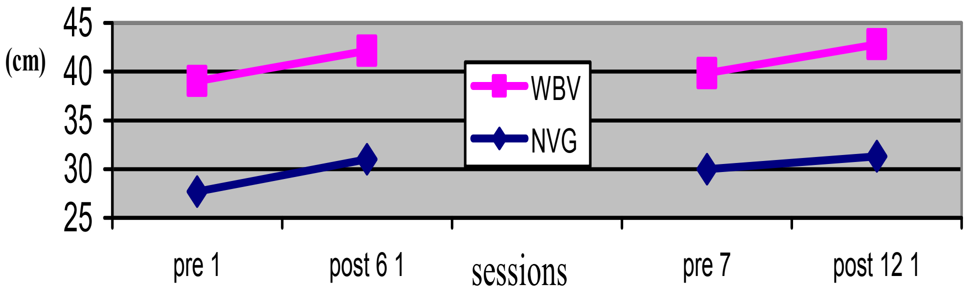

Fig.1. Time course of groups on hamstring's flexibility on total duration of experimental design

No significant interaction effect between group and time was found with respect to flexibility test after the 1est session (F= 2.621, p= .076). The repeated measures ANOVA revealed significant differences with respect to time (F=29.609, p=.000). The differences were significant between pre 1 vs post 1 min (F=96.013, p=.000), but not between post 1 min later vs post 15 min (F=.681, p=.417), and post 15 min vs post 30 min (F=3.442, p=.076). Inspection of mean scores revealed that the means S & R score at post 1 min was significantly higher compared to mean scores at pre test (figure 2). However, a different effect was revealed for each group separately

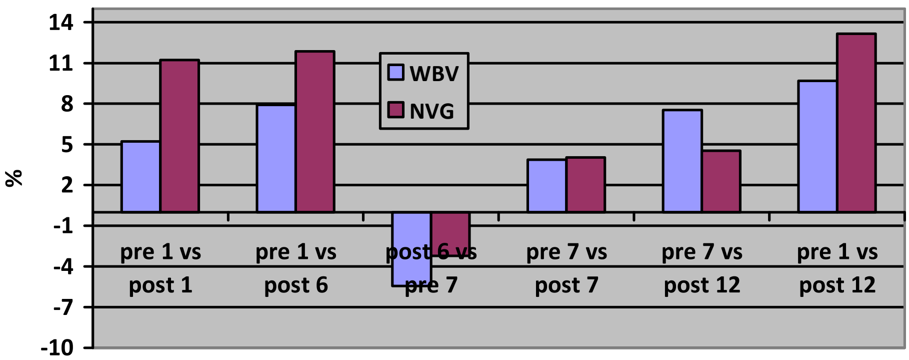

Fig. 2. Percentage improvement of groups on various measurements of experimental design

No significant interaction effect between group and time was found with respect to flexibility test after the 6th session (F= 2.006, p= .134). The repeated measures ANOVA revealed significant differences with respect to time (F=21.878, p=.000). The differences were significant between pre 6 vs post6 1 min (F=33.051, p=.000), post 6 1 min vs post 6 15 min (F=14.882, p=.001), but not between post 6 15 min vs post 6 30 min (F=.172, p=.682). Inspection of mean scores revealed that the means S & R score at post 6 1 min was significantly higher compared to mean scores at pre 6, and the mean score at post 6 15 min was significantly higher compared to mean score at post 6 1 min.

Significant interaction between group and time was found with respect to S&R after the end of 7th session (F= 3.317, p= .039, η^2= .311). The t-parameter estimates, however, revealed significant differences between group at pre 7 (t==3.800, p=.001), at post 7 1 min (t=4.352, p=.000), post 7 15 min (t==4.049, p=.000), and post7 30 min (t==3.900, p=.001). The repeated measures ANOVA revealed significant differences between a) pre 7 vs post 7 1 min (F=14.438, p=.003), but not for post 7 1 min vs post 7 15 min (F=. 449, p=.517), and post 7 15 min vs post 7 30 min (F=. 152, p=.704) for WBV group.

No significant interaction effect between group and time was found with respect to flexibility test after the end of 12th session (F= .285, p= .836). The repeated measures ANOVA revealed significant differences with respect to time (F=35.359, p=.000). The differences were significant between pre 12 vs post 12 1min (F=114.671, p=.000), and post 12 1min vs post 12 15min (F=5.067, p=.034), but not between post 12 15min vs post 12 30min (F=3.914, p=.059). Inspection of mean scores revealed that the means S & R score at post 12 1min was significantly higher compared to mean scores at pre 12, the means S & R score at post 12 1min was significantly lower compared to mean scores at post 12 15min. The mean scores of the groups and the total sample are presented in table 1.

Table 1: Descriptive data of two groups and the total sample in various measurements on sit and reach test (S & R) (cm)

	WBV (n=12)	NVG (n=14)	Total (n=26)
Pre sit 1	39.04 ± 5.58	27.71 ± 8.08	32.94 ± 8.99
post: 1min	41.08 ± 5.13	30.82 ± 7.50	35.56 ± 8.26
post1: 15 min	40.75 ± 4.86	31.71 ± 7.01	35.88 ± 7.55
Post1: 30 min	40.08 ± 4.90	32.43 ± 6.63	36.40 ± 7.23
Pre sit 6	40.79 ± 4.74	29.50 ± 6.40	34.71 ± 8.01
post6: 1 min	42.12 ± 4.79	31.00 ± 5.67	36.13 ± 7.66
post6: 15 min	42.42 ± 4.58	32.14 ± 5.08	36.88 ± 7.06
post6: 30 min	42.29 ± 4.55	32.11 ± 5.08	36.81 ± 7.02
Pre sit 7	39.83 ± 5.51	30.00 ± 7.36	34.54 ± 8.16
post7: 1 min	41.37 ± 4.69	31.21 ± 6.81	35.90 ± 7.78
post7: 15 min	41.54 ± 4.32	33.03 ± 6.07	36.96 ± 6.79
post7: 30 min	41.42 ± 4.06	33.71 ± 5.71	37.27 ± 6.29
Pre sit 12	41.00 ± 4.73	29.21 ± 5.28	34.65 ± 7.76
post12: 1 min	42.83 ± 4.28	31.36 ± 4.98	36.65 ± 7.41
post12: 15 min	43.29 ± 4.10	32.07 ± 4.89	37.25 ± 7.24
post12: 30 min	43.08 ± 3.92	31.68 ± 5.07	36.94 ± 7.33

Discussion

According to the results no significant interaction effect was found between group and time for the total duration of experimental design. However, significant differences were found with respect to time. It is mentioned that each group showed a significant improvement on hamstring's flexibility after these 6 training session in two weeks (p<.05) (figure 1). The percentage improvement was 7.89% and 11.87% for the WBV and NVG, respectively. However, the cessation of training (post 6 vs pre 7) had a significant negative effect on hamstring's flexibility on WBV group that revealed a decrease by 2.29 cm (5.44%) whereas NVG revealed no significant decrease by 1.00 cm (3.22%). Further, after the end of cessation of training of two weeks, the next training sessions (7th vs 12th) had a different effect on each group. WBV group revealed a significant improvement by 3.0 cm (7.53%) whereas, NVG revealed a difference of 1.36 cm (4.53%) (figure 1).

Although no significant interaction effect was found in each separate session an acute effect was found after the end of intervention program of 1est session. Each group revealed a significant improvement (p< .05) immediately after the end (1 min after) of intervention program. The percentage improvement was 5.22% and 11.22% for the WBV and NVG, respectively (figure 2). Further, after two weeks of training that means after 6 sessions, a positive effect was revealed in each group. The percentage improvement was 7.89% and 11.87% for WBV group and NVG respectively (figure 2). The cessation of training had a negative effect on hamstring's flexibility on both groups. The percentage decrease between post 6 measurement and pre 7 measurements was -5.44% and -3.22% for WBV and NVG, respectively (figure 2). However, each group regained this decrease and improved flexibility in post measurements after the end of the 7th session. This improvement of NVG (4.03%) was greater compared to those of WBV group (3.86%) (figure 2). But the most significant finding of this study was in the 2nd cycle of this training regime (7th – 12th session) where both groups showed significant improvement that was greater in WBV group (7.53%) compared with NVG (4.53%). However, the total improvement from the first session and after the end of twelve sessions was 9.70% and 13.17% in WBV group and NVG respectively (figure 2).

Our results support previous data of Kinser et al (2008) and Sands et al (2006; 2008) that showed increased flexibility on artistic gymnasts using simultaneous vibration and stretching. Further, our results in accordance with findings of Covert et al (2010) and Meroni et al (2010), which state that static stretching, can improve hamstring's flexibility and those of Covert et al (2010) that revealed significant improvements in hamstring length when using a single 30-seconds stretching dose 3 days per week for a 4-week training program. Also, our results confirms the results of previous study indicating that static stretching is an effective and efficient method of increasing hamstring muscle length (Davis et al, 2005). In our study percentage improvement on NVG was greater from those of WBV stretching group. A possible explanation for the greater increase in flexibility after the static stretching that applied by NVG may be the viscoelastic stress relaxation that occurs when the muscle tissue is kept stretched in a fixed position (Magnusson et al, 1995; 1996).

In addition, according to our results cessation of training had a negative effect on flexibility, a result that agree with data of Dastmenash & van den Tillaar (2010) that revealed a similar lose of flexibility on hamstring muscles although using a different training protocol. Further, maintenance of flexibility was showed in both groups 15 min and 30- minutes after the end of intervention program. This result opposed with finding of Depino et al (2000) which found that this effect lasted only 3 minutes after cessation of the stretching protocol.

Conclusion

Conclusively, results of our present study support that stretching combined with Whole Body Vibration is not the most effective method to improve flexibility mainly in artistic gymnasts. Maybe the fact that possesses an initial high level of flexibility is a restricted factor for further significant improvement. Further, a training effect was appeared in NVG that followed the traditional method of static stretching in our study. Further, cessation of training has a negative effect on hamstring's flexibility but this decrease disappeared with commence of training.

Practical Applications

The present study indicates that WBV combined with stretching and/or traditional method of stretching may be applied in training schedule to improve hamstring's flexibility in sports especially in cases where a high level of flexibility exist like artistic gymnastics. Future research is needed to reveal if different frequency and amplitude, and/or longer exposure to the vibration stimuli have an additive effect to maintain this improvement for longer time in trained artistic gymnasts and athletes of other sports.

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