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The effects of gymnastics and whole-body vibration exercises on some physical fitness parameters

Nurcan Demirel[1]

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Abstract

The purpose of this study was to comparatively analyze the effects of 6 weeks of gymnastics and whole-body vibration exercises on some physical fitness parameters. Twenty-two male subjects participated in this research (Age average 21.4 ± 2.4 and height average 1.75 ± 5.6 cm). Participants were randomly assigned to three groups; Gymnastics and Whole-body Vibration Exercise Group (GWBVEG, n=7), Gymnastics Exercise Group (GEG, n=8) and Control Group (CG, n=7). Muscle strength, endurance and flexibility were measured before and after 6 week-exercise periods. For data analyses Wilcoxon Signed Ranks Test was used in order to look at the differences among the dependent groups and Mann Whitney U test was used in order to to look at the differences among the independent groups. When the groups' post-tests for physical performance values were compared, it was observed that the improvement of muscle strength and endurance values of the GWBVEG group was significantly higher than the one for GEG and CG groups (p>0.05). As a result, it is suggested that the whole-body vibration in gymnastics can be considered as some important criteria for the improvement of endurance, muscle strength and flexibility.

Keywords: *Whole Body Vibration, Gymnastics, Endurance, Strength, Flexibility*

1. Introduction

Vibration exercises are used as a performance improvement method in sports and exercise sciences, especially after the year of 2000. It attracted the attention of researchers as a special exercise and workout method. Therefore, vibration exercises are currently part of many sports centers' programs as a popular exercise type. The effect of vibration exercise or of its training depends on the characteristics of the vibration (Kin İşler, A. 2007). Vibration is used in two different methods as an exercise and a training method. The first method is called "local vibration" practice. In this method, the vibration can be applied directly on the widest surface of the muscle needed for workout or on the tendon. Moreover, it can be applied by a hand-held vibration source. In the second method, which is called "whole-body vibration (WBV)", the vibration is applied by a vibration source, which is away from the target muscle (Demirel, N. et al. 2009, Demirel, N. 2009, Hannah, R. et al. 2013,). The importance of vibration exercises is the fact that they cause involuntary consecutive muscle contractions. These movements taking place in muscles cause tension in the tendons as well. This tension also helps beneath-abdominal muscles which are called "deep muscles", spinal muscles and facial muscles work. Therefore, vibration exercises strengthen the muscles by working them deeply in short periods of time (Bosco, C. et al. 1999).

Therefore, the purpose of this research is to comparatively analyze whether gymnastics exercises combined with whole body vibration exercises have an effect on physical fitness parameters.

[1] *Sorumlu Yazar,* Atatürk Üniversitesi, Spor Bilimleri Fakültesi, Antrenörlük Eğitimi Bölümü

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2. Material and method

2.1. Participants

Twenty two untrained male college students who enrolled in Physical Education and Sports program participated in this research. Average age of the subjects was 21.4 ± 2.4 years and average height was 1.75 ± 5.6 cm. Participants were randomly assigned to three groups; gymnastics and whole-body vibration exercise group (GWBVEG, n=7), gymnastics exercise group (GEG, n=8), control group (CG, n=7). There were no significant differences among the groups' baseline values of physical fitness parameters and body compositions (p>0.05).

To be eligible to participate in the study, subjects were required to meet the following criteria:

1) Participants' age ranging between 20-25 years old.
2) Participants not involving in any sport activities except for gymnastics class in their degree program.
3) Participants not being involved in any vibration and strength training for the targeted muscles during the six-month period prior to starting the exercise.
4) Participants not having any medical obstacle to use the vibrations-work-out tool or any back problems.

Written informed consent was obtained from all subjects after they had received a full explanation of the study procedures. Subjects did not change their usual daily activity during the period of the study. The study was performed in accordance with the Helsinki Declaration of 1975, and was approved by the Ethical Committee of the University.

2.2. Procedures

Study design

In this study, "pre-test, post-test controlled group" model was used.

Table 1. Exercise protocol

GROUPS	EXERCISE	INTERVAL AND PERIOD	INTENSITY
CWBVEG	•Calves •Deep Squat •Lunge (Right) •Lunge (Left) •Lateral Abdominals (Right) •Lateral Abdominals (Left) •Abdominal Crunch •Push Up •Triceps Dip •Hamstring Stretch	1 x 60	35 Hz - Low / High
GEG GROUP	•Calves •Deep Squat •Lunge (Right) •Lunge (Left) •Lateral Abdominals (Right) •Lateral Abdominals (Left) •Abdominal Crunch •Push Up •Triceps Dip •Hamstring Stretch	1 x 60	Body Weight
CG	-		

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After the pre-test, the subjects in the GWBVEG and GEG groups performed six-weeks of exercise training (Table 1), while the CG did not participate in any exercise training. During the training, all subjects were under direct supervision and were instructed on how to perform each exercise. A Power-Plate vibration platform (Pro 5, USA) was used to superimpose WBV on voluntary exercise.

2.3. Measures

Measurements of the participants' anthropometrics and physical fitness evaluations were made between 08:00-10:00 in the morning, without any liquid and food intake during 12-hours prior to the measurements. Measurements were taken while the participants had standard workout clothes (short and t-shirt) and no shoes on them.

Aerobic-Power Measurement:

Participants' aerobic-power was measured by 20 meter Shuttle Run-Test (The 20-MST was developed by Leger and Lambert (1982.)[20] in terms of ml/kg/min by calculating their maxVO_2 value.

Leg-Strength Measurement:

In measuring participants' leg-strengths, back and leg dynamometer (TK-5402 Takei, Japan) was used. Dynamometer was calibrated according to the leg length of the participant, then the participant applied maximum strength on the tool. The best result received by the participant after two trials was accepted as the highest value.

Right/Left Hand-Strength Measurement:

In measuring participants' right and left hand-strengths, hand dynamometer (Lafayette Instrument Company, USA) was used. The best result received by the participant after two trials was accepted as the highest value.

Flexibility Measurement:

Sit and Reach Test (TKK 5103 Trunk Flexion Meter, Japan) was used to determine the participants' flexibility. The test was repeated 3 times and the best result was accepted as the flexibility value.

2.4. Analysis

Non-parametric tests were used to analyse the data, which does not indicate normal distribution and homogeneity. Wilcoxon Signed Ranks Test was used to see the difference between the dependent groups and Mann Whitney U test was used to see the difference between the independent groups. Statistical analysis was carried out using SPSS version 18.0 (SPSS, Inc., Chicago, IL, USA).

Data are presented as means ± SD and significance level was set at $P<0.05$.

2.5. Results

When the GWBVEG group's pre-and post tests of physical performance values were compared as of Table 2; significant differences were observed in leg strength (161.5±22.4 kg and 188.6±22.9 kg, respectively), right (44.0±5.4 kg, 48.4±4.9 kg) left hand strengths (40.8±3.9 kg, 43.9±3.0 kg), flexibility (31.3±3.1cm and 34.4±3.7 cm, respectively) ($p<0.05$). When the pre and

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post tests for GEG Group's physical performance values were compared; while there was significant difference in leg strength (125.2±28.0 kg, 139.6±30.2 kg) and flexibility (31.4±5.4 cm, 35.8±5.3 cm) values, no significant difference was observed in others ($p<0.05$). When the pre and post tests for the CG Group's physical performance values were compared; while there was signicant difference in aerobic power (47.9±2.9 kg/m^2, 43.9±5.2 kg/m^2) and leg strength (156.9± 22.1 kg, 121.9± 49.7 kg), no significant difference was observed in others.

Table 2. Comparison of the Pre-and Post Tests for Physical Performance Values of the Groups

GROUPS		GWBVEG (n=8)		GEG (n=7)		CG (n=8)	
		Pre test	Post test	Pre test	Post test	Pre test	Post test
PHYSICAL PERFORMANCE VALUES							
Aerobic Power Kg/m²	X	46.3	48.1	42.3	43.2	47.9	43.9
	(SD)	5.5	2.7	5.5	4.2	2.9	5.2
	Z	1.014		1.014		**2.028***	
Leg Strength Kg	X	161.5	188.6	125.2	139.6	156.9	121.9
	(SD)	22.4	22.9	28.0	30.2	22.1	49.7
	Z	**2.371***		**2.524***		**2.028***	
Right Hand Strength Kg	X	44.0	48.4	39.4	40.8	43.7	45.3
	(SD)	5.4	4.9	4.1	4.6	9.7	11.9
	Z	**2.366***		0.491		0.676	
Left Hand Strength Kg	X	40.8	43.9	38.5	38.7	44.3	44.5
	(S)	3.9	3.0	4.7	4.8	12.3	10.6
	Z	**2.028***		0.210		0.169	
Flexibility Cm	X	31.3	34.4	31.4	35.8	16.6	18.7
	(SD)	3.1	3.7	5.4	5.3	3.8	4.3
	Z	**2.192***		**2.524***		1.183	

*p<0.05

Table 3. Comparison of Post Tests for Physical Performance Values of the Groups

GROUPS		GWBVEG (n=8)	GEG (n=7)	GWBVEG (n=8)	CG (n=8)	GEG (n=7)	CG (n=8)
		Post Test		Post Test		Post Test	
PHYSICAL PERFORMANCE VALUES							
Aerobic Power Kg/m²	X	48.1	43.2	48.1	43.9	43.2	43.9
	(SD)	2.7	4.2	2.7	5.2	4.2	5.2
	Z	**2.145***		1.665		0.405	
Leg Strength Kg	X	188.6	139.6	188.6	121.9	139.6	121.9
	(SD)	22.9	30.2	22.9	49.7	30.2	49.7
	Z	**2.546***		**2.942***		0.463	
Right Hand Strength Kg	X	48.4	40.8	48.4	45.3	40.8	45.3
	(SD)	4.9	4.6	4.9	11.9	4.6	11.9
	Z	**2.548***		0.319		0.231	
Left Hand Strength Kg	X	43.9	38.7	43.9	44.5	38.7	44.5
	(SD)	3.0	4.8	3.0	10.6	4.8	10.6
	Z	**2.027***		0.319		1.216	
Flexibility Cm	X	34.4	35.8	34.4	18.7	35.8	28.7
	(SD)	3.7	5.4	3.7	4.3	5.4	4.3
	Z	0.638		**3.006***		**3.240***	

*p<0.05

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When the post tests for GWBVEG and GEG Groups' physical performance values were compared as of Table 3; while no significant difference was observed in flexibility (34.4±3.7 cm, 35.8± 5.4 cm) value, there were significant differences in other values (p<0.05). When the post tests for the physical performance of the GWBVEG and CG groups were compared; it was found that while there was significant difference in leg-strength (188.6± 22.9 kg, 121.9± 49.7 kg) and flexibility values (34.4± 3.7 cm, *18.7± 4.3 cm) (p<0.01), other values had no significant difference. When the post-tests for the the physical performance values of the GEG and CG Groups were compared; there was a significant difference in flexibility (35.8± 5.4 cm, 28.7± 4.3 cm (p<0.05), while others had no significant difference.

3. Discussion

In a study conducted by Delecluse, et al. (2003), 67 inexperienced female subjects were divided into four groups as Whole Body Vibration (WBV, n=18), Placebo (PL, N=19), Resistance Workout (RES, N=18), Control (CO, N=12). Isometric strength. Dynamic strength and knee extensors' ballistic strength were measured before and after a 3-times a week applied exercise program during 12-weeks period time. WBV and placebo groups' exercises on vibration platform were static and dynamic knee extensor exercises by shortening the recess interval intensity or amplitude (2.5-5 mm), or by increasing the vibration frequency (35-40 hz). Although the exercises in the PL Group were done on vibration platform, only the sound of the engine was heard and a slight shake was felt. In the RES Group, knee extensors were worked out by dynamic leg-press and leg- extension exercises. In WBV and RES groups, isometric and dynamic knee extensor strength were increased respectively (16.6 _ 10.8%;9.0 _ 3.2%) ve (14.4 _ 5.3%; 7.0 _ 6.2%). Bounce strength was increased significantly only in WBV Group (7.6 _ 4.3%). In conclusion, it was assumed that the increase in muscle activities resulted from stimulating the propriospinal tracts that occurred in WBV arose from gaining strength through resistance exercises in the knee extensors of the untrained individuals (Delecluse, C., Roelants, A., Erschueren, S. 2003).

In another study conducted by Delecluse, et al. (2005), the participants who were 20 experienced sprint athletes composed of 13 males and 7 females, ranging between the ages of 17-30, were divided randomly into two groups as Whole Body Vibration (WBV, n=10, 6 male, 4 female) and Control group (CG, n=10, 7 male, 3 female). While the CG group attended the traditional training program existing in the 5-weeks trial period, the WBV group applied the WBV program 3-days a week before their training, in addition to their traditional workout. The vibration workout included static and dynamic leg exercises with no weight, which were applied on the vibration platform. According to the research findings; isometric and dynamic knee extensor and flexor strengths did not show any difference between the two groups. In addition, the duration for the initial action, start speed, initiation span and sprint run speed did not significantly change in the two groups. In conclusion, a 5-week WBV workout that was added to the traditional exercise program did not increase the speed-strength performance of the sprint athletes (Bogaerts, A. 2006, Delecluse, C., Roelants, M., Diels, R., Koninckx, E., Verschueren, S. 2005).

The purpose of the research conducted by Paradisis, et al. (2005) was to study the effect of a 6-week-vibrational training on sprint kinetics and explosive strength performance. 24 participants (12 males, 12 females) joined the research and they were divided into two groups as control (CO) and experimentation (WBV) groups. WBV group exercised on vibration platform during a 6-

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weeks period, 3 days per week, 16-30 minutes per day. While the amplitude of the vibration platform was 2.5mm, its momentum was 2.28g. The sprint performance was measured by 60m test and during the test; run time, run speed, step length and step sequence were measured. The explosive strength performance was determined by a vertical jumping test which in turn determines sprint height and sprint count at 30 seconds. Performances for 10m, 20m, 40m, 50 m and 60 m showed significant increase by 2.7% after 6-weeks WBV. While the step length and run speed increased by 5.5% and 3.6 %, step sequence decreased by 3.3% (p<0.05). While sprint height rose by 3.3%, explosive strength endurance increased by more than 7.8%. In conclusion, 6-weeks WBV resulted in significant differences in run kinematics and explosive strength performance (Paradisis, G., Tziortzis, S., Zacharogiannis, E. 2005).

The purpose of the referred study conducted by Roelants, et al. (2004) was to determine and compare the effects of Whole Body Vibration (WBV) and fitness exercise performed during 24-weeks period and 3 times per week on body composition and muscle strength. 48 untrained females (age 21.3 +/- 2.0) participated in this study. WBV group (n=18) did weightless static and dynamic exercises on vibration platform. The Fitness Group (n=18) participated in standard cardiovascular (15-40 min.) and resistance workout program (20-8RM). The Control Group did not participate in any exercise program. The WBV and the Fitness groups produced significant strength increase. As a result; 24 WBV brought a slight increase in extensor strength. Strength increase was similar after vibration exercise and fitness program (Roelants, M., Delecluse, C., Verschueren, S. 2004).

When studies investigating the chronic effects of WBV were reviewed, it was observed that WBV as a workout model was applied at least 10 days, and at most during 6 months periods. While WBV being applied for short periods of 10 days resulted in increases of the average strength, strength-out and sprint height; its 3-5 days application during 6 months period caused significant increases in explosive strength, isometric and isokinetic strength and sprint height. When the acute and chronic effects of vibration application on flexibility studies were reviewed for; it was observed that the applied vibration resulted in significant progress (Akimoto, T. et al. 2003, Cardinale, M., Lim, J. 2003, Fjeldstad, C. 2009, Kerschan-Schindl, K.S. et al. 2001, Konak, A., Çiğdem, Y. 2005, Lamont, H.S. 2007, Paradisis, G., Zacharogiannis, E. 2007, Rubin, C. et al. 2003, Russo, C.R. 2003). In a study where acute WBV in different frequencies (25, 34, 44 and 47 hz) and at steady amplitude (3-5 mm) on movement width were used; while significant progress was observed on right leg for 34, 44 and 47 hz, there was no significant progress for 24 hz. Moreover, it was reported that tension exercises which were applied with local vibration (3 mm, 44 hz) and without vibrational workout during 3 weeks, 3 days per week with 2-4 repetitions and 6-7 seconds resulted in the increase of the leg's flexibility by 2.4% without vibration and by 8.9% with vibrational application. It is explained that one reason for the observed development in flexibility through acute and chronic vibration application can be the increase in pain threshold as a result of the vibration and accordingly, the decrease in the pain during movement of the stretching. During the stretching movements, the experimental subjects may have forced themselves to the limit and this might result in the increase of the range of motion and flexibility. Furthermore, researcher proposed that another reason for the progress achieved in flexibility could be the fact that the application of vibration caused vasodilatation in the vessels and this in turn may have resulted in the increase of blood circulation and muscle temperature (Burns, P.A. et al. 2005, Cardinale, M., Rittweger, J. 2006).

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In a study by Kinser et al. (2008), conducted with 22 female Gymnasts athletes with their ages ranging between 11.3 ± 2.6 years old and their body weights ranging between 35.3 ± 6.11 kg; In this study, flexibility, explosive strength and simultaneous vibration-stretching effects were investigated. It was concluded that although vibration and stretching will not alter the explosive strength, they can still increase the flexibility to a large extent (Kinser Ann, M. et al. 2008).

The study conducted by Frank, H., Moos, B. (2003) was designed to investigate the short-term effects of the 8-weeks Whole Body Vibration (WBV) protocol on female competitors' muscle performance and flexibility. 26 young female athletes (21-27 years old) were randomly divided into vibration and control groups. Vibration practice was performed by sitting on vertical vibration platform for 3 days per week during a total of 8 weeks. As a result, after 8 weeks of WBV training; bilateral knee extensor strength, vertical jump and flexibility of the young female athletes significantly increased while there was no change in the control group Frank, H., Moos, B. (2003). This study's results support the results of present research.

The purpose of the research made by Sands et al. (2006) which was carried out with 10 elite male gymnasts, was to determine whether there was static vibration support in static stretching or not. As a result, the vibration in elite male gymnasts demonstrated that it can be a promising tool, which increases movement width beyond the flexibility that was achieved by static stretching (Sands, W.A., Mcneal, Jeni R., Stone, Michael H., Russell, Elizabeth M., Jemn, Monem. 2006). These findings show similarity with the literature and with the findings of our research.

4. Conclusions

It should be considered that vibration trainings lead to special adaptations on human skeletal muscles and have importance on strength development (Michael, J. et al. 2014).

The characteristics of vibration include the above-mentioned implementation methods of vibration and its intensity. The two most important factors, which determine the intensity of the vibration are frequency and amplitude. As known; soft tissues, muscles, bones and joints in the human body have the feature of resisting to the mechanical energy produced as a result of vibration up to a certain level, of extinguishing this energy and of absorbing it. From this point, it emerges that during the application of WBV vibration, since the source of vibration is far from the target muscle, a portion of the frequency and amplitude for that applied vibration is absorbed by the soft tissues, muscles, bones and joints; and therefore, the intensity of vibration, which reaches the target muscle and causes a vibration on it, cannot be clearly determined. However, it can be more precisely said that, during local application of vibration, since the vibration is applied directly to the muscle or to the tendon, the achieved effect is created by the intensity of the applied vibration (Demirel, N. 2009, Cardinale, M., Lim, J. 2003, Osawa, Y., Oguma, Y. 2011, Torvinen, S. 2003, Verscheuren, S. et al. 2004, Yılmaz, C. 1997, Zhang, L. et al. 2014).

Exercise protocol is important for these exercises. Many researchers pointed out the importance of vibration training for strength workout (Cardinale, M., Lim, J. 2003, Power Plate Next Generation 2009, Show, C.C. 2005). When the literature is reviewed, it becomes clear that the effects of vibration training usually were examined on sedentary lifestyle and on athletes; our study examined its effects especially with gymnastics, and our findings were interpreted in relation to and in the light of the information received from literature. Therefore, its contribution to the sport of gymnastics is extremely important. It can be observed from this study that, when averages are examined, vibration exercise had positive effect on most parameters and statistically

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significant differences as well. The reason for this can be the fact that the exercise period might not have been sufficiently long. Therefore, repeating this study for different exercise periods will strengthen our research.

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