

# The effect of three methods of warm-up on the anaerobic power, agility, speed, flexibility and fatigue index of elite female volleyball players

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**Abstract.** The main purpose of this study was to evaluate the effects of warm-up on the anaerobic power, agility, speed, flexibility and fatigue index elite female volleyball players. To this end, 20 of the volleyball players aged 18 to 30 years and at least 5 years of experience in the sport voluntarily participated in this study. Each of the warm-up method consists of three sessions per week for a week and then test. Warm-up exercise includes warm-up routine, vibration, and a combination of both. The aerobic power, agility, speed, flexibility and fatigue index were measured after each training session. For data analysis of repeated measures and the significance of the results of the Bonferroni post-test were used. Base on the results after three warm-up exercise, no significant difference was observed between aerobic power, agility, and speed. No significant difference was observed in the flexibility and fatigue index. In general, it can be concluded that the combination of warm-up with vibration can improve aerobic power, agility and speed will be. Hence, it can be offered as a new method of warm-up in the different sports to athletes and coaches. Therefore, combined warm-up with vibration increases blood flow to active muscles and nerve receptors and increases the speed of nerve impulses.

**Keywords.** Aerobic power, agility, flexibility, speed, vibration, warm up.

## Introduction

The warm up before exercise or sports competition for athletes is a common. The desirable effect of warm-up includes increased flexibility, range of motion, blood flow and also body temperature all of which are widely accepted as key factors in improving performance (CeEmiliano et al., 2008; Curry et al., 2009; Faulkner et al., 2013). Athletes often use different ways of warm-up designed by educators to follow up (Kendall &

Gothe, 2015). The outcome and the exact mechanisms of the ways of warm-up are still unknown (Merriman & Jackson, 2009).

The whole body vibration (WBV) is a relatively new method to increase muscle strength, power and physical performance of individuals of any age as well as people with physical impairments (Bosco et al., 1998; Ronnestat, 2004). Whole body vibration has been posed as a useful way to increase muscle strength, vertical jump mechanical capabilities bones, bone mineral density and body balance, explosive power, speed, flexibility, agility and speed (Darryl et al., 2004; Torvinen et al., 2002; Blain et al., 2006). Some researchers reported significant increase in vertical jump after a meeting of the 4-minute whole body vibration training (Bosco et al., 2000). Other did not observe significant change in the vertical jump, after 60 seconds the whole body vibration training twice in 30 seconds with 2 minutes rest between repetitions and frequency of 26 Hz (Betts & Maak, 2009). Bosco et al. (1999) reported a significant increase in the reported speed and explosive power in a vibration training session on the women's national volleyball team players. Cardinal & Lim (2003) reported a notable improvement in vertical jump, speed and muscle power in a study on male athletes after 10 days Vibration Training. Colson et al. (2010) examined the effect of 4 weeks of whole body vibration on performance basketball players. The significant increase was observed in isometric strength and maximal voluntary knee extensor strength in their study.

In general, it can be seen in the available studies that the vibration training, different applications of vibration frequency, amplitude or power equipment has been used and it is still not clear what frequency and amplitude can have the greatest impact (Cardinal & Lim, 2003; IUO ET AL., 2005). For example, it was observed that a training protocol with the frequency, scope and specific situation

had a significant increase in performance sports such as speed and explosive power, while the same training protocol with the same frequency and in the same posture in another study, by applying the 1 mm range and a significant increase has not been observed (Bosco et al., 1998; Darryl et al., 2004). In order to develop physical fitness and skill Volleyball, special abilities are required including explosive power that is of the most vital needs of each volleyball player (Shandell & Manama, 1971). That's why a lot of research have been done to develop and strengthen physical fitness factors. The research that has been done in this area is the use of whole body vibration machine as a useful tool to increase and development of physical fitness, motor (Darryl et al., 2004; Torvinen et al., 2002; Blain et al., 2010). Most of the research has been carried out on the performance of some sports like hockey (Cochrane & Stannard, 2005), skiing (Mahieu et al., 2006), basketball (Colson et al., 2010) or in non-athletes (Sarshin et al., 2010), the elderly (Cardinal et al., 2008) and some research on vertical jump volleyball players (Blain et al., 2006; Feland & Jeffry, 2006).

Given the differences in the carried out researches, yet there is not an inconclusive results regarding the effects of vibration on physical fitness factors affecting the various sport disciplines. The combined effect of conventional warm-up or vibration alone has not been studied which is going to be addressed in this research. Due to the effects of vibration on the body's circulation and blood flow associated with indicators of overall athletic performance, it is likely that the accumulation of metabolic factors associated with fatigue can be reduced or delayed using vibration (Rittweger, 2010). In this research the question arises "is there a difference in the effect of common warm-up to whole-body vibration training on aerobic power, agility, speed, flexibility fatigue female volleyball index exists or not?"

## Methods

Given the importance of research, its design was quasi-experimental that was conducted with a group of subjects and in three stages. Independent variables consist of three warm-up methods (conventional warm-up, combined warm-up and vibration commonly associated with vibration), respectively. Anaerobic dependent variables include the maximum, minimum, average, agility, speed, flexibility and the fatigue index. The statistical population included 30 female athletes in the sport of volleyball. Of the population, 20 were selected voluntarily as samples after the initial assessment and measurement of height, weight, waist and hip circumferences. Selection criteria include: (1) age between 18 to 30 years (2) 5 years' experience in volleyball (3) having no joint – muscle damage.

It should be noted that persons were given consent forms, questionnaires and a history of injury before the initial evaluation. Vibration device model "Crazy Fit Massage Machine" (Made in Taiwan) was used in this study. Before the training, participants to be familiar with the tests, athletes participated in the test one day before the test, then three times a week from a week's warm-up exercise programs conventional warm-up and the composition of vibration along with their conventional vibration. The exercises used in this program included the conventional warm-up exercises used in (jogging, static stretching and exercise), vibration and warm-up combined with the vibration. Then to measure the variables, the tests' research were used.

### Program and doing common warm-up

The warm-up program includes a 5 minute jogging and 30 static stretching. Stretch was 15 seconds per move starting and changing time and preparing for the next move was 5 seconds. Out of total 30 moves, 10 moves to stretch the upper limb, 10 moves to stretch lower limb, 5 moves to stretch the head and neck and 5 moves to stretch the body. Program of exercise movements includes a minute of running in place and then warm-up the joints of the neck, shoulder girdle, elbow, wrist, torso, thighs, knees and ankles and a total of 20 moves and each move was performed 10 numbers (Dalrymple et al., 2010).

### Implementing vibration training

Vibration Training includes stand on the vibration with a frequency of 26 Hz and amplitude uncertain range for 4 minutes at 110°. The goniometer was used to determine the squat 110°. To be familiar with the vibration device before the main exercise, subjects implemented squat 110° with zero frequency and amplitude on vibration device (Cochrane & Stannard, 2005).

### How to implement the hybrid program

First, warm-up routine was carried out as described above, immediately after vibration training program was conducted.

### Implementation of anaerobic power test

Running based Anaerobic Sprint Test (RAST) was used to measure anaerobic power and capacity. The player runs 35 meters with a frequency of 6 times by 10 seconds of rest between repetitions. And then due to the time gained from repetition from 35 meters, power is obtained according to the formula: 
$$\text{power} = \frac{\text{weight} \times \text{distance}^2}{\text{time}^3}$$
 (Gharekhanloo et al., 2009). According to the instructions below, maximum power, minimum power, average power and fatigue index

are clear: maximum repetition between 6 frequency = maximum power, minimum power = minimum power between 6 reps, 6 reps, average power = total power divided by 6.

$$\text{Fatigue index} = \frac{\text{Maximum power} - \text{Minimum power}}{\text{total running time for the 6 stage}} = 1$$

For the interpretation of test results, the above equation was used. The research findings of 676 to 1054 watts of for the maximum and 319 to 674 minimum range of were reported. In this test, the higher the average power rating reflects the better ability of the athlete to maintain anaerobic performance. Test (RAST with great reliability  $r = 0.88$ ) and anaerobic endurance estimate is considered appropriate test (Alessandro et al., 2009).

### Implementation agility test

To measure agility test, line contact was used which is especially for volleyball players. In this test, the subjects stand in the middle point of the line that was drawn to a distance of 3 meters from each other and with the command of tester, timer will start and the athlete from the side runs with maximum speed between two lanes and touch lines a sweep period. Testing was one minute and contact time between the lines were considered as a record of athletes. These test was repeated 2 in which the rest intervals was 3 minutes between repetitions and best record was recorded for him (Gharekhanloo et al., 2009).

### Implementing flexibility test

Flexibility test was conducted in two ways: 1-Opening the trunk 2- lifting shoulder test.

*Trunk Extension Test:* Athlete lies on the ground on abdomen. Auxiliary assistant, legs and thighs keeps constant the athlete on earth. The participants bent the elbow and puts his hands behind neck, breathing and pick up the upper body as far as possible from the ground and

keeps the situation. Using the ruler against the athlete, the distance from athlete chin to the ground is recorded as points (Gharekhanloo et al., 2009).

*Pick up the shoulders test:* Athlete with hands stretched above the head and while holding a piece of wood in his hands, lies on the ground on stomach. He brings up the stick as far as possible while the chin, face and forehead still sticking to the ground. The distance between the pieces of wood in the hands of the athlete to the ground is recorded as points (Gharekhanloo et al., 2009).

### Implementing the speed test

To measure the speed, the 20 meter sprint test was used. So its implementation is that the subject stands behind the start line and subjects begin to run at full speed with the alert (run). At this moment the timer starts. With a distance of 20 meters and crossing the finish line, the timer stops working. The resulting time is recorded in seconds and hundredths of seconds (the best record of three repetitions) (Mohammadi & Salehi, 2009).

### Data analysis

Repeated measures analysis was used to examine variables and as the significance, the difference between the three groups, Bonferroni test was used to compare each pair of measurements (Table 3).

### Results

Table 1 shows the demographic characteristics of participants.

The variables that were examined in this study include maximum aerobic power, anaerobic power, at least, moderate aerobic power, agility, flexibility and fatigue index. The descriptive indicators mean, standard deviation of the variables in the three conventional warm-up and vibration common position combined heat and vibration are shown in Table 2.

**Table 1.** Demographic characteristics of participants.

Variables	Mean	SD	Minimum	Maximum
Age (Year)	23.45	4.08	18.00	30.00
Height (cm)	163.35	6.83	148.00	177.00
Weight (kg)	60.83	7.25	45.60	71.70
BMI	18.60	2.01	14.25	21.21
Waist Circumference (cm)	73.15	5.93	63.00	82.00
Hip Circumference (cm)	97.30	4.01	90.00	103.00

**Table 2.** Descriptive statistics measured variables.

Variables	Conventional warm-up		Vibration		Conventional warm-up and vibration		
	Mean	SD	Mean	SD	Mean	SD	
Maximum Anaerobic Power (W)	48.97	243.96	57.96	220.13	53.94	250.56	
Minimum Anaerobic Power (W)	34.99	132.04	35.76	122.95	29.26	140.24	
Average anaerobic Power (W)	37.22	183.16	43.71	167.29	39.30	18694	
Agility (Round per min)	3.14	45.55	3.33	45.60	2.95	47.05	
Speed (s)	0.21	3.87	0.28	4.10	0.23	4.02	
Flexibility (cm)	Trunk	7.35	37.40	9.54	37.10	2.95	39.60
	Shoulder	10.02	42.90	11.45	43.45	8.75	47.05
Fatigue Index (W)	0.89	2.48	0.85	2.11	1.03	2.48	

**Table 3.** The results of repeated measurements.

Variables	Sum of Squares	df	Mean of Squares	F	p
Maximum Anaerobic Power	10248.37	2	5124.18	5.472	0.008
Minimum Anaerobic Power	2993.10	2	1496.55	3.259	0.049
Average Anaerobic Power	4347.99	2	2174.00	9.507	0.0001
Agility	29.03	2	14.52	3.858	0.030
Speed	0.56	2	0.28	5.760	0.007
Upper Body Flexibility	74.53	1.54	48.29	2.056	0.155
Shoulder Flexibility	203.23	1.20	169.67	2.744	0.106
Fatigue Index	1.81	2	0.91	1.458	0.264

## Discussion

### Effect of warm-up method on the maximum, minimum, and average anaerobic power

The effect of three methods of warm-up on the anaerobic power was investigated and the results showed that there is a significant difference between anaerobic powers maximum, minimum and mean different ways after the warm-up exercise. According to comparing pairs of groups in repeated measures, it was clear that anaerobic power maximum and minimum is significantly more than vibration in conventional warm-up combined with common method. Anaerobic average in conventional warm-up methods with vibration and conventional warm-up routine has a significant increase compared to the vibration only. The results of research conducted by Needham et al. (2009), Avery et al. (2006), Holt & Lambourne (2008) and CeEmiliano et al. (2008) are not consistent with results of present study and findings of Kortney et al. (2010). The reason for being not consistent can be caused by variables that affect the warm-up activities. Time warm-up, warm-up intensity, content, time interval until the main activity are variables that can be used according to the characteristics of the athlete, the type and desired sports, weather conditions, ambient temperature and objectives of the training session or change their race (De Ruyter et al., 2002). McMillan et al. (2006) believes that one of the reasons for the improvement, after vibration training, is muscle activity and reduction of

opposing muscle activity. However, it is possible that the frequency and amplitude and duration of the exercise can affect on performance. Torvinen et al. (2002a) has not observed significant changes in deep jump frequency range of 40 Hz to 25 mm<sup>2</sup> for 4 minutes. But in another study, Torvinen (2002b) with a frequency of 15-30 and 10 mm range showed a significant increase in power for 4 minutes deep jump. It is possible that the position on the device and the type of training on the vibrator results affect the changing results. Delecluse et al. (2005) believes that the long-term standing on a vibrating device leads to activation of all motor units, eventually causes the fatigue and reduced strength. In the present study, since activity is a short-term one, the time has a positive impact anaerobic power. Researchers have stated the following reasons as possible mechanisms of the effects of whole body vibration on anaerobic power. Activation of muscle spindles causes the reflection of the vibration tonic (tonic contraction), which is located in an arc stretching and this practice is observed when applying vibration to the muscles (Cardinale & Wakeling, 2005). Reducing electromechanical delay (EMD) muscle stimulation could be the reason for the increased sensitivity of muscle spindles. The EMD is less, the speed of production more power which means more aerobic power (Luo et al., 2005). Also during stimulation with vibration, vibration induced tonic vibration reflex. This reflex causes an increase in the use of single and multi-synaptic muscle through understanding and facilitates an increase on the reflex activity of the motor neurons (Giorgos & Elias, 2007). The findings show that the increase in activity Ia afferent neurons and descending directives for

loops or motor neuron terminals acceptable reason for improvement of motor excitability and increased activity after using vibration (McMillian et al., 2006).

### **Effect of warm-up on agility**

In this study, there is a significant difference between agility in vibration exercises and combined warm-up with vibration. So that the method of combining warm-up with vibration than the vibration only increased the agility. Pasanen et al. (2009) in their study of the effect of six months of warm-up on neuromuscular system for hockey players, a significant increase was observed in speed and agility. If Vetter (2007) study, with six warm-up protocol Sprint did not find significant differences in female and male students.

The mechanism that explains the effects of whole body vibration, the potential is after activation. The mechanism of potential after activation includes myosin light chain kinase activity that closes myosin regulatory light chain from the point s1 to the point s2 (phosphorylcholin). The sensitivity of binding bridges on calcium ion has been increased and this is the reason for the increase in the formation of actin binding - myosin (Sale, 2002). So the potential after activation is effective on muscle fibers type II and so on quick moves and explosive short-term (Fleming, 2008). In summary, given that few studies regarding the effect of warm-up combined with vibration training on agility performance report and there is the need for more research in this field. But in the study by warm-up and vibration, warm-up combination with vibration improved agility performance.

### **Effect of warm-up on speed**

The effect of three training methods on volleyball players were investigated in the present study and no significant difference was observed between the speed in the conventional and vibration in the two warm-up exercise. The results showed that the conventional method of warm-up significantly reduces the speed rate than the vibration method. The result of our research was consistent to Fletcher & Jones (2004), Joorkesh (2007) which observed a significant difference in the speed. In contrast, some studies found no significant difference in speed time (Little & Williams, 2006). The difference could be due to the type and mode of warm-up, for example, in one study, the most effective ways to reduce warm-up time was using static stretching and sprinting 40 yards, 10 yards, respectively (Bullis et al., 2007). The researchers justifies this finding as the women body's response to stretch. On the other hand, there is evidence to suggest that vibration adversely affects the speed and no significant difference was observed in the speed after vibration training (Delecluse et al., 2005) that correspond with the current study. In this research,

vibration training increases the speed time in 20 meters. In contrast, some studies have observed a significant difference in the speed (Giorgos & Elias, 2007; Cardinale, 2002) that this difference may be related to changes in parameters such as frequency, amplitude and duration of standing on the vibrator.

### **Effect of warm-up on flexibility**

In the present study, there was no significant difference between the mean flexibility in the shoulders and upper body of training protocols. In the study of Sullivan et al. (2009) a significant increase was observed in the flexibility of the hamstring after warm-up which were inconsistent with results of present study. This can be explained in different subjects, as well as factors such as the type and duration of stretching warm-up program, content of warm-up and warm-up time and the main activity and the type and nature of the field of sports. Sticky- elastic properties is often an explanation for nature of muscle-tendon units. Static stretching leads to relax the muscle-tendon units and reduces shrinkage and increases range of motion (Church et al., 2001). This shrinkage after static stretching is one of the reasons for its negative effect on performance. Another negative factor on performance is neural inhibition (Behm et al., 2001; Fowles et al., 2000). Also in this study, there was no significant difference in the effects of vibration on the flexibility that are consistent with Herda et al. (2009) on the effects of vibration on flexibility and are not consistent with the research achievements such as Cochrane & Stannard (2005) and Cardinale & Wakeling, (2005). Static and dynamic stretching is among standard practices prior to exercise to increase flexibility. It is said that mechanical stretch the connective tissue between the muscle tendons could decrease the hardness and other inactive skeletal structures disable that brings together the range of motion (Nelson et al., 2005). Given that vibration training requires mechanical stretching, there is good justification for this theory based on increased flexibility through vibration. Training, In support of this theory, a 2.8 percent improvement has been reported in sitting and getting hands after whole-body vibration training (Cochrane & Stannard, 2005).

### **Effect of warm-up on the fatigue index**

According to the present study, there is no significant difference in the fatigue index in the three training methods which was consistent with Cafarelli & Layton-Wood (1986) and Kelly et al. (2010), but not consistent with Rittweger et al. (2003). McKenna et al. (1997) planned to study the effects of different warm-up after a 10-second high-pressure test on maximum power capacity without lactic acid and lactic acid. Although they are only a 5-minute warm-up program and with varied intensity, concluded

that the warm-up activity significantly expands both variables. Another hypothesis of this study was to evaluate the effects of vibration and warm-up combined with vibration training on fatigue index. Kelly et al. (2010), in his research dealt with the effect of warm-up bicycle ergometer with vibration compared with the peak isokinetic torque at different speeds and fatigue in the knee extensor exercises trained men and women, and did not observe differences between bicycle ergometer and vibration protocols on the speed and fatigue index. His vibration protocol includes a period of 30 seconds in isometric squat for 5 minutes and warm up with 5 minutes of pedaling on a bicycle ergometer includes 65 to 85 percent of maximum heart rate. To compare the fatigue of the subjects, 50 times in succession knee extensor Introverted at an angle of 240° that early repeated an average of 3 to 3 the final iteration was recorded as an indicator of fatigue. The results of this was consistent with the present study, although different in terms of content, time and intensity of warm-up program (Kelly et al., 2010). Some studies have reported that muscle fatigue is accelerated as a result of vibration training (Samuelson et al., 1989) and is somewhat contrary to some physiological studies in vibration training, when tendons are associated with isometric contractions, motor output and power generation increased (Bongiovanni et al., 1990; McCloskey et al., 1974). In addition, the short time spent on vibration can return to normal the scope and to a lesser extent the power generation used in a tired muscle isometric contractions, but it just takes 10 seconds and after this time, reversed and fatigue increases rapidly (Bongiovanni et al., 1990).

In general, it can be concluded that conventional methods of warm-up combined with vibration have a greater impact on anaerobic power, speed and agility of elite female volleyball players. Commenting on the results of the study, it can be argued that the conventional method of warm-up combined with vibration increases the temperature in the body and the blood flow in active muscles and increasing in the body's internal temperature, in turn, increases the sensitivity of nerve receptors and increases the speed of nerve impulses. Also according to conducted studies, the improvement of physical function after warm-up exercises with vibration increases co-operation of motor units, increases stretching reflecting, increases the collaborated muscles, and promotes muscle in the inhibiting the opposite muscle. Therefore, the use of these two combination could be a new way to improve sports performance that should be of interest to coaches and researchers.

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