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The immediate effect of induced muscular fatigue on static and dynamic balance and core strength in male volleyball players: An experimental study

Gaurav Bhatnagar
Professor, Department of Musculoskeletal Physiotherapy, Maharashtra Institute of Physiotherapy, Latur, India.

Rajesh Kumar Sahu
PhD Research Scholar, Department of Physiotherapy, Nims College of Physiotherapy, Nims University Rajasthan, Jaipur, India
Corresponding author email: rajeshksahu1991@gmail.com

Mohammed Rafi
Professor and Principal, Department of Community Physiotherapy, Maharashtra Institute of Physiotherapy, Latur, India.

Shital Ghule
Assistant Professor, Department of Community Physiotherapy, Maharashtra Institute of Physiotherapy, Latur, India.

Varsha Ahirwal
BPT Student, Maharashtra Institute of Physiotherapy, Latur, India.

Abstract

Introduction: Muscular fatigue causes impaired joint proprioception and postural control which can affect performance. Fatigue affects the capacity of the muscle to generate force which ultimately leads to injuries and diminish performance. The effect of fatigue on static and dynamic balance in volleyball players was inadequately known. Aim: To assess the effects of induced muscular fatigue on static and dynamic balance and core strength in volleyball players. Methodology: Twenty male volleyball players were included in the study according to inclusion criteria. Dynamic balance by functional reach test, static balance by single leg stance and strength of core were evaluated before and after inducing the fatigue. Fatigue was induced by asking the participant to perform the

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squats till RPE of 10. Results: On data analysis using paired t test, a marked decrease in the single leg stance time mean from 26.63 seconds before fatigue to 22.55 seconds after inducing fatigue ($p<0.05$) was observed. A reduction in the functional reach distance covered by subjects from 31.8cms before fatigue to 29.33cms after inducing fatigue ($p<0.05$) was observed. A decrease in the core muscle strength from 42.25 mm Hg before fatigue to 41.85 mmHg after fatigue ($p<0.05$) was observed. Conclusion: The study concluded that there was a marked reduction in both static and dynamic balance and core strength after inducing muscular fatigue in male volleyball players.

***Keywords*---**Core Strength, Dynamic Balance, Muscular Fatigue, Rate of perceived exertion, Static Balance.

Introduction

Volleyball is known to be one of the most popular played sports amongst men and women[1], in the world due to its accessibility to a wide age group and also because it can be played both outdoor and indoor with minimal equipment requirements[2]. The sport demands fast repetitive movements and high vertical jumping and landing. Players in a volleyball match need to perform service, pass the ball, spike and attack. These movements require intense vertical jumping and landing by the player.[3] It was observed that the players directly involved in attack or defense in the volleyball game were more prone to injuries. According to survey conducted on the members of twelve teams participating in inter university tournament held in Dr. Ambedkar University Maharashtra in 2007, it was found that lower injuries were predominant and 58% among injured players were in the age range of 22 to 25 years [4].

Many sports requires sudden change in direction, starting and immediate stopping, keep moving the object, and maintaining the body at a particular position which demands good balance skill and is very important in performing many sports skills successfully. In a match the loss of balance must be regained as soon as possible and if the athlete fails to do so in a brief period of time may affect performance and also leads to injury[5]. It is common to observe a fifty percent decrease of force during a maximum contraction of many mixed muscles over a period of a few seconds which is known as fatigue [6]. Localized developing muscle fatigue has been defined as maximal force reduction after prolonged use of a muscle[7]. Postural stability[8], muscle coordination[9] and limb velocity control and acceleration[10] is impaired due to progressive fatigue of a muscle. Proprioceptive and kinesthetic properties of joints are altered due to fatigue which in turn decreases neuromuscular control, thus increasing injury risk[11].

The stability of core is the ability to avert buckling of lumbar-pelvic hip complex and maintaining balance after disorder[12]. The person's center of gravity is located at this point and where all the movement begins[13]. So controlling the center of gravity, the point around which the body maintains balance to perfection is the key. A reduced strength of the core and stability results in poor technique, which makes a player susceptible to injury[14]. There are limited studies describing the

effect of stability of the core on the match performance[15]. A study showed that intense running to exhaustion induces core muscle fatigue in endurance runners[16]. Many studies have showed that induced fatigue had an effect on dynamic balance in elderly person and athletes[17,18] using various methods, but no such studies were carried out on the volleyball players. Therefore the purpose of this study was to access immediate effect of induced fatigue on static and dynamic balance and core strength in volleyball players.

Materials and Method

An experimental design was chosen for the study. Approval from the institutional ethical committee of Maharashtra Institute of Physiotherapy, Latur was obtained before recruiting the participants. An informed consent was taken from all the subjects.

Procedure

Twenty male volleyball players were included according to inclusion criteria i.e. subjects Aged 18-25 years, playing at least district level with minimum 3 years of experience and playing at least four times a week. The subjects having lower extremity musculoskeletal injuries or a head injury in the last 6 months were excluded. The static balance was measured by single leg stance and the dynamic balance was measured by the functional reach test. The aneroid sphygmomanometer was used to measure lumbar core strength. The outcome measures were measured pre and post fatigue during the same session. For the single leg stance, subjects were asked to stand barefoot on dominant leg (which was found by the ball kick test) and perform single leg stance on the firm surface with knees apart. Subjects were instructed to look straight in front and focus on any object at a distance of 1 meter without touching hands on the body. Time was noted until the subject could maintain the balance in unilateral stance as mentioned above without moving[29].

Functional reach test was recorded by calculating the difference between the initial and final point of an outstretched arm in maximum forward reach, in standing position with base of support fixed. For functional reach test the participants were instructed to stand parallel to the wall with foot 10 centimeters apart, keeping the arm which was near to wall at 90 degrees and contra lateral upper limb in neutral and they were asked to reach as far as possible without taking a step, raising the heel and losing balance. Excursion of arm from start point to end point was measured. Subjects were instructed to avoid shoulder protraction. A point at tip of the middle finger was marked on the wall in starting position. The forward reach for three seconds was maintained and middle finger tip was again marked at this end position. Distance between the first and second point was measured[19].

Aneroid sphygmomanometer was used to measure the core strength. Participants were asked to lie in crook lying position with the sphygmomanometer cuff inflated to 40 mm Hg placed under the lumbar spine. Subjects were asked to press the cuff by tucking in abdomen and activate core muscles. The participants maintained the pressure between 40 to 50 mmHg for 10 seconds. The pressure

should not be more than 50 mm Hg as rectus abdominis gets activated and not lower than 40 mm Hg as it produces arching of the lumbar spine. If subjects were not able to maintain the pressure for 10 seconds, then 3 minutes rest was given and again asked to hold the pressure at a lesser value for 10 seconds[20]. The muscular fatigue was induced by asking subjects to perform ninety degree squats with both the upper limbs in ninety degrees of forward elevation and to continue it till rate of perceived exertion measured by modified Borg scale reaches 10/10 that is very strong[21]. The subjects were asked to squat, as if they were sitting on a chair in which tibia remains proportionately vertical.[22] The single leg stance test, functional reach test and core muscle strength testing were repeated immediately after the protocol and readings were recorded.

Statistical Analysis

Descriptive statistical data was presented in the form of mean+/- standard deviation and difference percentage were calculated and presented. Paired T test was performed to measure pre and post performances to find out the significant effect on dependent variables with alpha set at $p < / = 0.05$. For all the statistical analysis, $p < 0.05$ was considered as a statistically significant.

Results

- **Single Leg Stance**

Table 1. Comparison of pre and post values

	MEAN	SD	t VALUE	P VALUE	INFERENCE
PRE	26.63	8.83			
POST	22.55	7.75	9.722	< 0.05	Significant

Table 1. Showed the mean and standard deviation of pre test and post test were 26.63±8.83 and 22.55±7.75 respectively. The t test value is 9.72 and P value = 0.00000002336 which is > .05 which showed that there was a significant difference between pre and post test values of single leg stance.
Figure 1. Single Leg Stance (Pre and post values)

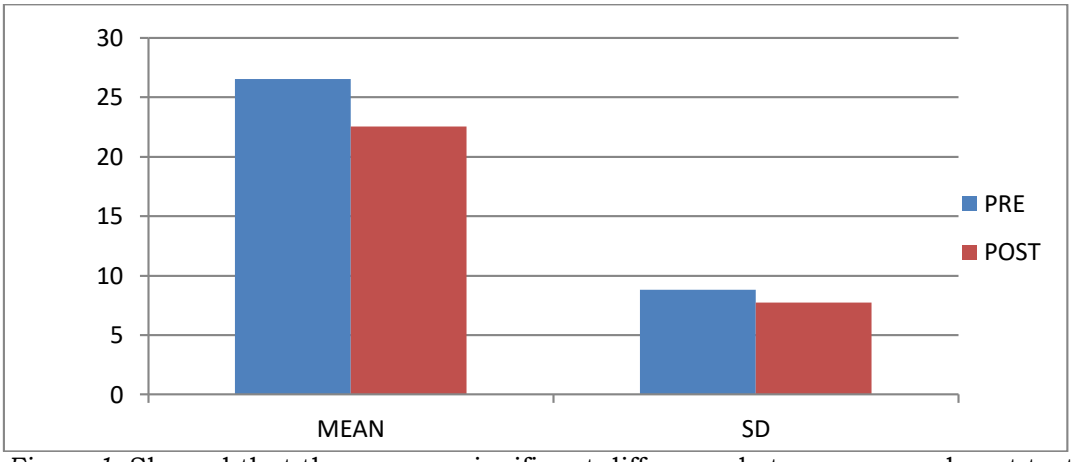

Figure 1. Showed that there was a significant difference between pre and post test values of single leg stance.

- **Functional Reach Test**

Table 2. Comparison of pre and post values

	MEAN	SD	T VALUE	P VALUE	INFERENCE
PRE	31.8	5.29			
POST	29.33	4.55	2.217	< 0.05	Significant

Table 2. Showed the mean and standard deviation of pre test and post test were 31.8±5.29 and 29.33±4.55. The t test value is 2.21 and P value = 0.0405312 which is > .05 which showed that there was a significant difference between pre and post test values for functional reach test.

Figure 2. Functional Reach Test (Pre and post values)

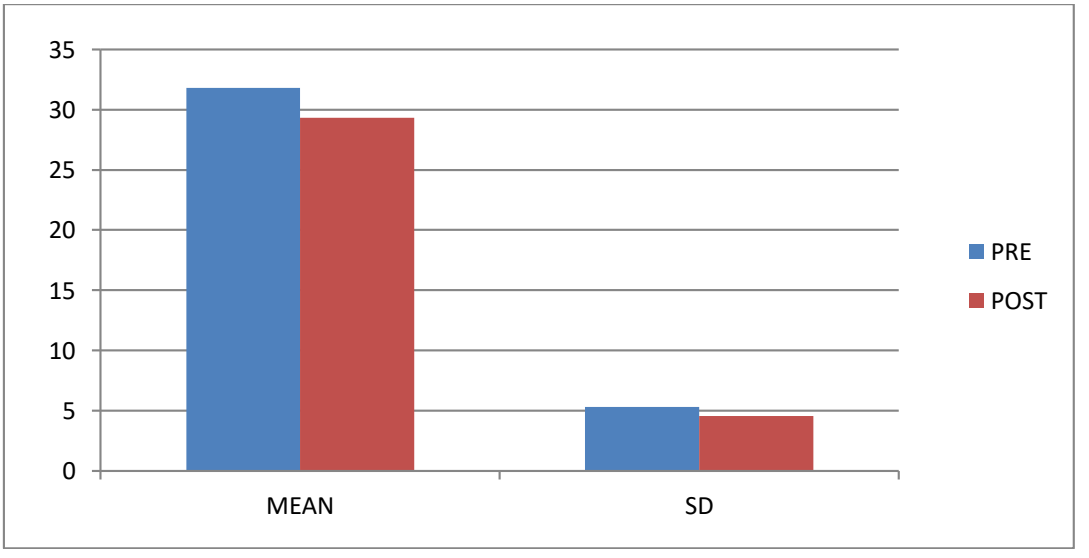

Figure 2. Showed that there was a significant difference between pre and post test values for functional reach test

- **Lumbar Core Strength**

Table 3. Comparison between pre and post values.

	MEAN	SD	T VALUE	P VALUE	INFERENCE
PRE	42.25	1.01			
POST	41.85	0.95	2.9	< 0.05	Significant

Table 3. Showed the mean and standard deviation of pretest and posttest were 42.25±1.01 and 41.85±0.95 respectively. The t test value is 2.9 and P value = 0.009828 which is <.05 which showed there was a significant difference between pre and post test values for lumbar core strength.

Figure 3. Lumbar Core Strength (Pre and post values).

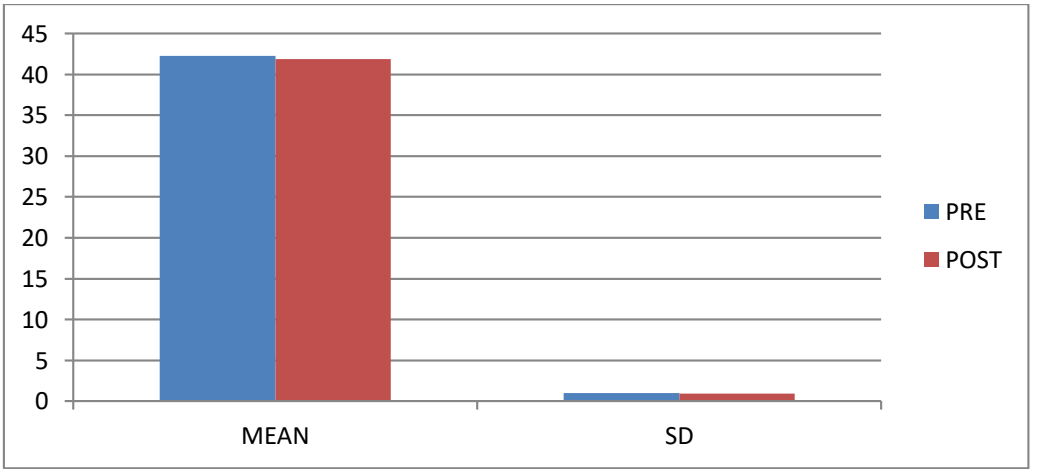

Figure 3. Showed there was a significant difference between pre and post test values for lumbar core strength.

Discussion

The results showed marked decrease in the single leg stance time which suggests reduction in the ability of the player to maintain a stable posture. Postural control or balance is person's ability to withstand forces that intimidate to disturb the body's structural equilibrium[23]. It can be either static or dynamic. Dynamic balance is the ability to maintain stability while body is in motion from one point to another. Reduced functional reach distance may be due to diminished ability to maintain balance because of shifting of line of gravity outside the base of support in fatigued state. This may be because the eccentric and isometric muscle activity by both the type 1 and type 2 muscle fibers were affected in fatigued state. Studies reported that effects of fatigue were condition specific[24]. A study concluded that there was a decrease response of muscle to frequent stimuli and

was mirrored by a progressive decrease in amplitude of motor unit potentials leading to muscular fatigue[25]. This takes place when repeated muscle contraction occurred either statically or dynamically against an imposed load. When the muscles that control balance get fatigued, may affect the vestibular, somatosensory, and visual systems hindering proper balance control[26]. The muscle spindle discharge increases due to muscular fatigue disturbing the afferent feedback to CNS which causes changes in joint Proprioceptive and kinesthetic properties thus affecting postural control[27]. Lastly by applying fatigue protocol on the muscles controlling the joint causes the sensory receptors to send messages to the CNS resulting in the reduced neural transmission speed in afferent and efferent neurons ending in a muscle group resulting in decreased dynamic balance control. In the current study, the imposed load was the persons own body weight. Ideal squat requires more trunk forward flexion to maintain the balance and stronger contraction of the quadriceps to brace the load of the pelvis posterior to the knee joint axis. Repetitive squatting may lead to fatigue of all lower limb muscles. Calf and thigh muscles fatigue affects postural sway in standing.

There was a difference found in the lumbar core muscle strength from 42.25mmHg to 41.85mmHg which was statistically significant. Few studies have shown that core stability was beneficial for musculoskeletal system functioning, as it maintains low back health, prevents knee ligament injuries. It has also been concluded that decreased core stability may predispose to lower limb injuries and that appropriate training of core muscles may reduce lower extremity injuries[28]. Fatigue leads to reduction in muscle glycogen after prolonged exercise. This depletion of glycogen occurs even if sufficient oxygen is available energy generation by aerobic pathways. Fatigue causes increase in the level of blood and muscle lactic acid and H+ concentration in the exercising muscles. This changes the myofilaments activity and impairs muscle performance even when the nerve impulses continue to fire. Fatigue is accompanied by decrease in neural activity when all motor units are maximally activated. Local fatigue might also produce an effect at another site in the body. Fatigue at the proximal and distal area also affects the core stability making a player at a risk of back injuries and spinal damage. Thus it is important that our everyday tasks and daily activities should be organized and planned in such a manner that it reduces the detrimental effects of fatigue on our musculoskeletal system as with our other body systems[29].

Conclusion

The study concluded that muscular fatigue causes significant reduction in static and dynamic balance and also has an effect on reduction in core strength as seen in male volleyball players.

Limitations

Only male subjects were included in the study.

Recommendations

Both genders can be included in future studies. It is also suggested to examine the athletes balance in real conditions and at different stages of volleyball. We recommend sports coaches to use field test to measure fatigue and prevent the

subsequent damage. Studies can also be carried out using different fatiguing protocols.

Ethical Approval
Ethical Approval done by Institutional Ethics Committee of Maharashtra Institute of Physiotherapy, Latur (India) No.: IEC/2019/UG/-10/19 Dated: 24/03/2019

Conflict of Interest
The authors confirm that they have no conflicts of interest and no funding to declare.

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