

# Effects of 4 Weeks of Neuromuscular Training Vs Functional Balance Training on Static Balance in Those with Chronic Ankle Instability

Dr. Tabish Fahim (PT)<sup>1</sup>, Dr. Priyanka Chugh (PT)<sup>2</sup>

<sup>1</sup>Assisnant Professor, Noida International University, Noida, Uttar Pradesh, India

<sup>2</sup>Assistant Professor, Banarsidas Chandiwala Institute of Physiotherapy, Kalkaji, New Delhi, India

**Abstract:** ***Purpose and Background:** The purpose was to make training adaptations more specific and applicable for FAI. The primary purpose of this study was to determine which training (Neuromuscular training or Functional Balance Training) is better when training balance for functional ankle instability. **Design:** Pre-test post- test experimental design. **Method:** 30 subjects with self-reported CAI (18-25 years) were recruited according to the inclusion and exclusion criteria. 15 subjects with CAI (8 males and 7 females, age= 23.6±1.54yr.) in NMT and 15 subjects with CAI (8 males and 7 females, age= 23.33±1.58yr.) participated in this study. **Outcomes:** Static balance on lower limb. Before and after the intervention, all the subjects completed the following test: for static balance- Single Limb Stance Test. **Results:** Result of this study showed a significant improvement in static balance in both the groups. **Conclusion:** The results of this study demonstrate that regardless of different training protocol (NMT and FBT), statistically significant improvements in balance were achieved by both the groups. Following the training the SLST time significantly improved in the both the training group. Thus we can say that both neuromuscular training and Functional balance training can give better results in improving static balance.*

**Keywords:** Neuromuscular training, Functional Balance training, Functional Ankle Instability, Single Limb Stance Test.

## 1. Introduction

With increasing amounts of leisure time and the current emphasis on physical fitness, the incidence of sports injuries has increased dramatically. The ankle joint is the second most common injured body site in sport with lateral ankle sprains being the most common type of ankle injury.<sup>1</sup> Thus, ankle sprains are one of the most frequently encountered musculoskeletal injuries. Ankle sprains, account for between 3% and 5% of all Emergency Department attendances in the UK, with about 5,600 incidences per day.<sup>2</sup> It has been estimated that an ankle injury occurs every day per 10,000 of the population.<sup>3</sup> In the acute phase, ankle sprains are associated with pain and loss of function, and one quarter of all injured people are unable to attend school or work for more than seven days.<sup>5</sup> Ankle injuries account for five percent of all sports injuries and two billion dollars in medical costs annually.<sup>6</sup> In addition to its financial costs, ankle sprain can result in significant sequel, including time lost to injury and long-term disability in up to 50% of cases.<sup>7</sup> Yet an estimate 55 % of people who experience an ankle sprain will not seek professional treatment.<sup>8</sup> This is unfortunate since most of these individuals are young athletes with good rehabilitation potential.

## 2. Literature Survey

Functional ankle instability (FAI) is defined as recurrent or the subjective feeling of “giving way”.<sup>9</sup> Tropp et.al, described FAI as joint motion beyond voluntary control not necessarily exceeding physiological range of motion and MAI as ankle joint motion that exceeds the physiologic range.<sup>10</sup> Clinical diagnosis of FAI is predicted on the patient’s self-reported episode of “giving way”. Some authors reported symptoms of functional instability in the absence of mechanical instability.<sup>11</sup> Vaes recently reported

only 35% of 117 functionally unstable ankle demonstrated mechanical instability.<sup>12</sup> Several studies support the notion that mechanical instability alone is of little clinical significance. However the combinations of mechanical instability and decreased neuromuscular control resulting from deficits in joint proprioception may result in functional instability of the ankle joint.

Functional training is the science of training the body to meet the specific demands of life and sports.<sup>14</sup> Both static and dynamic movement patterns are trained simultaneously in Functional balance training (FBT). Therefore, we can say that functional training incorporates many types of training, including functional balance training, and further—and importantly—the broad umbrella of “functional training” trains movement specific to sport, recreation, and daily life. Postural stability improved after subjects performed functional balance training programs, both with or without exercise sandals. Training with exercise sandals might not be any more effective in improving postural stability than performing functional balance training without exercise sandals.<sup>15</sup>

Neuromuscular training (NMT) is defined as training enhancing unconscious motor responses by stimulating both afferent signals and central mechanisms responsible for dynamic joint control.<sup>16</sup> Neuromuscular training programs are designed to reduce injury risk, and include interventions that focus on increased control of the center of mass. As the center of mass moves away from the base of support, there is an increased potential for biomechanical deviations to occur in the lower extremity. An improved ability to control this movement has the potential to decrease excessive forces on the lower extremity and ultimately decrease injury risk.<sup>17</sup> Several studies support the use of interventions such as neuromuscular training programs (NMT) to reduce the

incidence of lower extremity injuries.<sup>18</sup> Acute lateral ligament injuries of the ankle are best treated nonsurgically, with peroneal strengthening and neuromuscular training.<sup>13</sup> The 6-week dynamic neuromuscular training program improved parameters of ankle joint sensorimotor control in an athlete with chronic ankle instability.<sup>19</sup>

Over the past 4 decades --- hundreds of articles dealing with lateral ankle sprains and ankle instability, yet epidemiological evidence shows no reduction in injury rates. Research showing the improvement in static balance ability independently is widely available, yet little or no research has directly examined the relationship between neuromuscular training and functional balance training. An understanding of the differences in the two different training groups (NMT and FBT), will allow the clinician to establish a comprehensive and effective rehabilitation for the athletes.

### 3. Problem Definition

To find the effects of 4 weeks of neuromuscular training vs functional balance training on static balance in those with chronic ankle instability.

## 4. Methodology

### 4.1 Subjects

Thirty subjects were selected by simple random sampling for study after signing the informed consent according to the inclusion and exclusion criterion and were assigned to two groups (NMT and FBT). The subjects in each group were similar in terms of age, and height. It consisted of both male and female participants. All the subjects were recruited with self-reported CAI from various universities, and colleges in Delhi and NCR region. Inclusion criteria were a history of more than one ankle sprain and residual symptoms, including subsequent episodes of the ankle giving way. Also included were self-reported symptoms of disability due to ankle sprains qualified by a score of 90% or less on the Foot and Ankle Disability Index (FADI) and the FADI Sport surveys.<sup>20</sup> All subjects had no history of lower extremity injury, including ankle sprain, within the past 6wk, no history of lower-extremity surgery, and no balance disorders, neuropathies, diabetes, or other conditions known to affect balance. If a subject reported bilateral ankle instability, the self-reported worse limb was used for analysis and training. The subjects were excluded if history of head injury (concussion) is present within the previous 12 weeks.<sup>21</sup> Before testing, all subjects signed an informed consent form approved by the university institutional review board.

Once informed consent was obtained, subjects were randomly assigned to either a NMT group or a FBT group. The randomization was concealed and prepared by an independent investigator. The NMT group consisted of 8 males and 7 females (age=23.6±1.54, lower limb length=85.46±7.10), and the FBT group consisted of 7 males and 8 females (age=23.33±1.58, lower limb length=86.66±8.23).

### 4.2 Variables

The independent variables were neuromuscular training, and functional balance training programme. Independent variable was static balance in lower limb.

### 4.3 Procedure

The potential volunteered candidates were explained the nature and the purpose of study and those agreed to participate were given the screening questionnaire (FADI score), to judge their suitability for the study. Eligible candidates underwent consent taking. Descriptive variables of all subjects, such as age, height, and sex were recorded. Subjects performed 1 practice session to familiarize themselves. The entire process consists of three phases of Pretest, Intervention and Posttest.

### 4.4 Exercise protocol

#### a) Neuromuscular Training Group

The neuromuscular group was participated in triweekly training sessions for a total of 12 sessions. It consists of lower extremity strength training, and core stability training, in which subject had performed one core stability exercise with all the lower limb exercises. The core stability component was divided into 5 phases of progressive exercises. 2 or 3 days were spent on each phase. 5 phases of core stability component were Swiss ball back hyperextension, Swiss ball back hyperextension with ball reach, Swiss ball hyperextensions with back fly, Swiss ball hyperextensions with ball reach lateral and Swiss ball hyperextensions with lateral ball catch.

The lower extremity strengthening program consists of following exercises. These exercises were squats (3 sets × 5 reps), Gluteal/hamstring raises (3 sets × 5 reps), Band ankle inversion/eversion (3 sets × 5 reps), 30-cm box lateral step-down (heel-touch) (3 sets × 5 reps), Lateral lunges (3 sets × 5 reps), and Walking lunges (3 sets × 5 reps).

#### b) Functional Balance Training Group:

The functional balance group was participated in triweekly training sessions for a total of 12 sessions. Exercises performed by these training groups included the Achilles stretching (3 sets × 20 sec), Short-foot concept contractions (3 sets × 60 sec), High knee walking (10 m), Lateral side step (10 m), Walking exercises (forward and backward) (10 m), Lunges (3 sets × 5 reps), and Squats (3 sets × 5 reps)

All training sessions began and ended with Achilles stretching. Subjects then practiced the short-foot maneuver before performing functional balance training exercises. The short-foot position was achieved 3 times, and each contraction was held for 60 seconds. During these contractions, subjects were instructed to pull the arch of the foot up by shortening the length and narrowing the width of the foot without flexing the toes.

#### c) Data analysis

All data were analyzed using statistical tests, which were performed using SPSS 19.00 software package. Demographic data of subjects including age and gender,

involved and dominant leg were descriptively summarized to project the results. The dependents variables for the statistical analysis were analyzed using parametric tests like Independent T-Test and Paired T-Test. The data was analyzed both between and within the groups. A 0.05 level of significance was used for all comparisons.

## 5. Results

### 5.1 Demographic data

30 patients were recruited for the study and assigned to group1 (NMT) and group2 (FBT) with 15 in each group. Mean and standard deviation of age and limb length (LL) in NMT group was  $23.6 \pm 1.54$  and  $85.46 \pm 7.10$  respectively, and for FBT group was  $23.33 \pm 1.58$  and  $86.66 \pm 8.23$  respectively. After analysis it was found that there was no statistically significant difference between the NMT and FBT group with respect to age and LL ( $t=0.465$ ,  $p=0.645$  and  $t=0.427$ ,  $p=0.672$  respectively). Subjects were equally distributed between NMT and FBT groups in terms of age and RLL. (figure1)

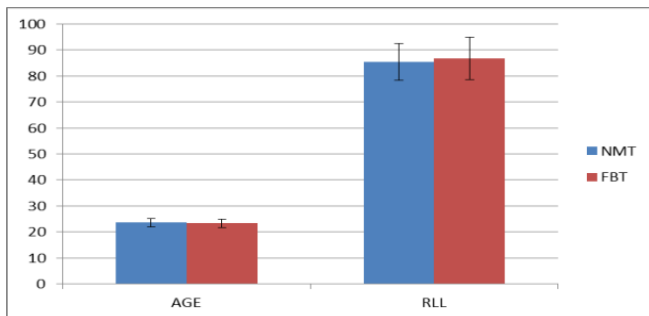


Figure 1

### Between group comparison of SLST

Mean and SD of pretest SLST of right leg and left leg in NMT group was  $15.04 \pm 6.83$  and  $14.82 \pm 7.10$  respectively, and in FBT group was  $13.44 \pm 5.79$  and  $15.31 \pm 5.54$  respectively. After analysis it was found that there was no significant difference between the groups for the pretest score for right leg and left leg of SLST ( $t=0.69$ ,  $p=0.49$  and  $t=0.21$ ,  $p=0.83$  respectively).

Mean and SD of posttest SLST of right leg and left leg in NMT group was  $22.89 \pm 6.18$  and  $22.52 \pm 6.07$  respectively, and in FBT group was  $20.3 \pm 4.75$  and  $21.95 \pm 6.24$  respectively. After analysis it was found that there was no significant difference between the groups for the posttest score for right leg and left leg of SLST ( $t=1.28$ ,  $p=0.20$  and  $t=0.25$ ,  $p=0.80$  respectively). (table 2, figure 2)

Table 2

	Group1 Mean±SD	Group2 Mean±SD	't' value	p value
SLSTR0	15.04±6.83	13.44±5.79	0.693	0.494
SLSTR4	22.89±6.18	20.3±4.75	1.288	.208
SLSTL0	14.82±7.10	15.31±5.54	0.213	0.833
SLSTL4	22.52±6.07	21.95±6.24	.252	.803

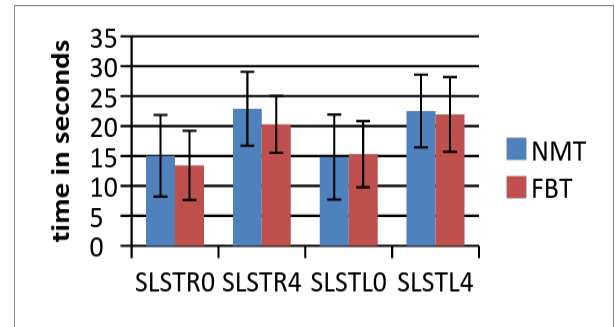


Figure 2

### Within group comparison of SLST in Group 1

Mean and SD of pretest and posttest SLST scores of right leg in NMT group was  $15.04 \pm 6.83$  and  $22.89 \pm 6.18$  respectively, and in left leg was  $14.82 \pm 7.10$  and  $22.52 \pm 6.07$  respectively. Within group analysis for group1 showed highly significant difference between the pre and posttest SLST scores of both right and left leg ( $t=7.90$ ,  $p=0.0001$  and  $t=7.83$ ,  $p=0.001$  respectively). (table 3, figure 3)

Table 3

	Pretest Mean±SD	Posttest Mean±SD	't' value	p value
SLSTR	15.04±6.83	22.89±6.18	7.901	.0001
SLSTL	14.82±7.10	22.52±6.07	7.834	.001

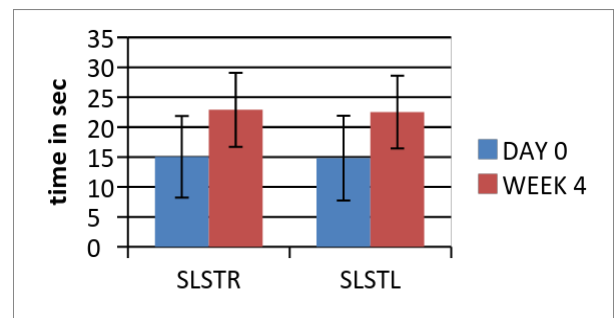


Figure 3

### Within group comparison of SLST in Group 2

Mean and SD of pretest and posttest SLST scores of right leg in FBT group was  $13.44 \pm 5.79$  and  $20.3 \pm 4.75$  respectively, and in left leg was  $15.31 \pm 5.54$  and  $21.95 \pm 6.24$  respectively. Within group analysis for group2 showed highly significant difference between the pre and posttest SLST scores of both right and left leg ( $t=8.039$ ,  $p=0.0001$  and  $t=7.982$ ,  $p=0.0001$  respectively). (table4, figure5.4)

Table 4

	Pretest Mean±SD	Posttest Mean±SD	't' value	p value
SLSTR	13.44±5.79	20.3±4.75	8.039	.0001
SLSTL	15.31±5.54	21.95±6.24	7.982	.0001

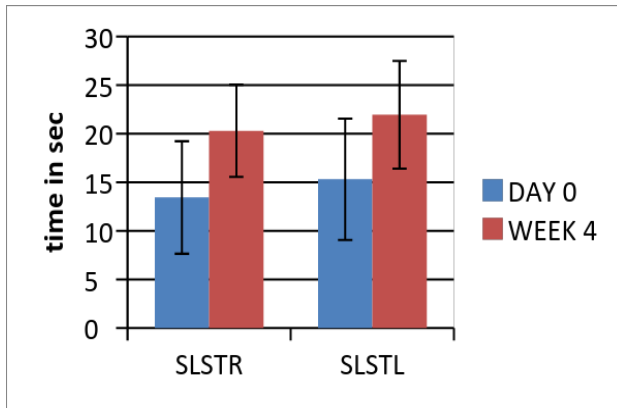


Figure 4

## 6. Discussion

The results of this study demonstrate that regardless of different training protocol (NMT and FBT), statistically significant improvements in balance were achieved by both the groups. Following the training the SLST time significantly improved in both the training group. Various reasons can be attributed to the improvement in static balance within each group. It has been discovered that the plantar surface of the foot plays a critical role in providing sensory input to central nervous system for balance and postural control. There are different types of mechanoreceptors present on the sole of the foot, which are responsible for sending somatosensory inputs to the brain by sensing pressure and stretching motion in the tissues that surround them. These plantar inputs are the dominant sensory information for balance when the body is standing still on a fixed firm surface or moving through the environment. Weight bearing exercises also stimulate joint mechanoreceptors leading to improved proprioceptive inputs and hence proprioception.

Our subjects might have developed new long-term muscle activation patterns after functional balance training. Muscle activity has improved after coordination training with static and semi-dynamic exercises. Osborne et al reported decreased onset latency of the tibialis anterior muscle after ankle disk training in subjects with FAI. In addition, Eils and Rosenbaum suggested that co-activation of ankle muscles increased in subjects with FAI after coordination training. This improved co-activation might have been responsible for improving postural stability in subjects with FAI. Based on the results of these studies, we contend that postural stability improvements might have resulted from improved foot and ankle muscle activity after 4 weeks of training. This improved muscle activation likely occurred while subjects were performing the exercises with the short-foot technique, as well as while subjects performed single-limb testing without the use of the short-foot position. Subjects might have increased activation in muscles responsible for performing the short-foot maneuver without actually shortening the A-P plane of the foot and narrowing the M-L plane of the foot during single-limb stance tests.

We had our subjects performed functional balance exercises while using the short-foot position for 12 sessions over 4 weeks, which might have allowed our subjects more time to learn new muscle activation patterns associated with this

technique. In addition, our subjects were instructed not to shorten and narrow the arch of the foot during single-limb stance tests, allowing them to concentrate on remaining as motionless as possible during the tests. The design of our study did not allow us to determine the effectiveness of the short-foot maneuver, as our results indicate that the functional balance exercises were responsible for postural stability improvements. In addition, neither subjects with stable ankles nor those with FAI had previous experience performing these exercises with the short-foot position. All subjects, regardless of ankle stability, might have responded to functional balance training similarly as a result of being introduced to these new movements and muscle activations for the first time.

The main findings of this study is in accordance with the conclusion of Thomas B. Michell et al.<sup>22</sup> They reported that Postural stability improved after subjects performed functional balance training programs, both with and without Exercise Sandals. However, findings of this study were not in accordance with conclusion of Rothermel et al.<sup>22,25</sup> They reported that 4 weeks (12 sessions) of single limb balance training with the short-foot maneuver did not improve single-limb postural stability in healthy subjects, whereas training without the use of the short-foot position did improve single-limb postural stability in healthy subjects. Rothermel et al.<sup>22,25</sup> speculated that the short-foot technique might have caused their subjects to focus on muscle contractions instead of remaining as motionless as possible during single-limb stance tests.

On detailed analysis we found that there were discrepancies between groups, though statistically non-significant. Marginally better improvements in NMT group can be explained on the basis that NMT incorporates lower limb exercises as well as core stability exercises with Swiss ball as a part of training. The unstable characteristics of these balls provide an environment to stimulate more motor units. The greater the instability, the greater the muscle recruitment is because of stabilization requirement. Core stability and strength are required for trunk rotation and postural control while standing or moving, and has significant importance for daily life activities, athletic performance, and the rehabilitation and protection from LBP. The Canadian Society for Exercise Physiology (CSEP) recommended to instability resistance exercise to train core muscles for athletes and sedentary people.

In a study it was established an isokinetic profile of trunk rotation strength in 109 elite male and female tennis players aged 11–54 years. The men had symmetrical strength between the forehand and backhand directions, and the women had only small (4–8%) differences in strength between these directions. The authors suggested that core-stabilization programs should focus on both directions of trunk rotation to enhance muscle strength and balance.<sup>26</sup> Our program incorporated various medicine ball exercises to improve core strength and stability.

Strength gains can be achieved not only by resistance training but also by neuromuscular training (Behm & Anderson, 2006).<sup>26</sup> Instability resistance training can load extra stress on the neuromuscular system. The aim of the



neuromuscular training is to improve coordination of synergists, agonist, antagonist, and stabilizers muscles, and also to increase recruitment or activation of motor units. Therefore, muscles may be used effectively with less movement uncertainty, resulting in energy conservation and movement efficiency (Rutherford & Jones, 1986). Carter et al (2006) stated that maintaining the stability of the body while performing a movement with Swiss ball mainly activates the local muscles. These local muscles are responsible for proprioception and sustaining stiffness through the spine and postural control.

On Single Limb Stance Test, static balance improved in both the groups in almost similar pattern in both the groups. No differences existed between the two groups when measured on SLST. The inability to maintain quiet stance during SLST has been consistently been shown to be associated with ankle instability.

One important observation of this study was that significant improvement occurred from day 0 to week 4. These findings suggest that 4 weeks of training is sufficient time to promote reflex muscular activation patterns necessary for the maintenance of posture and balance.<sup>30</sup>

In our study 73.33% subjects suffered from functional ankle instability in their dominant leg. Ekstrand and Gillquist<sup>31</sup> found that the dominant leg sustained significantly more ankle injuries than the non-dominant side in male soccer players. But, Beynnon et al<sup>6</sup> found no influence of limb dominance on ankle sprains in the study of collegiate soccer, field hockey, and lacrosse athletes.

### Clinical Relevance

Sports physiotherapist, sports trainers, coaches and others in situation where they are unable to decide which type of training is more beneficial for their athletes, they should be aware of the impact that Neuromuscular training and Functional balance training are almost equally effective in improving static balance. Functional balance training is easier to perform as compared to neuromuscular training, thus it can be used for older or weaker people for improving balance.

### 7. Future Scope

Generalizability of the results should be increased by carrying the study on large sample size. Studies can be done for longer durations (8 to 12 weeks), to make the picture of results more clear.

### 8. Conclusion

The results of this study demonstrate that regardless of different training protocol (NMT and FBT), statistically significant improvements in balance were achieved by both the groups. Following the training the SLST time significantly improved in the both the training group. Thus we can say that both neuromuscular training and Functional balance training can give better results in improving static balance.

### 9. Acknowledgment

We express our sincere thanks to Dr. Faizan Ahmad and Dr. Ruchika Gupta for helping in the study process.

### 10. Conflict of Interest

None

### References

- [1] Fong DT, Hong Y, Chan LK, Yung PS, Chan KM: A systematic review on ankle injury and ankle sprain in sports. *Sports Med* 2007, 37:73-94.
- [2] Cooke MW, Lamb SE, Marsh J, Dale J: A survey of current consultant practice of treatment of severe ankle sprains in emergency departments in the United Kingdom. *Emerg Med J* 2003, 20:505-507.
- [3] Kannus P, Renstrom P. Treatment for acute tears of the lateral ligaments of the ankle: operation, cast or early controlled mobilization. *J Bone Joint Surg [Am]* 1991;73-A:305-12
- [4] Lynch SA, Renstrom P. Treatment of Acute Lateral Ankle Ligament Rupture in the Athlete: Conservative vs. Surgical Treatment. *Sports Med* 1999; 27:61-71.
- [5] De Bie RA, de Vet HC, van den Wildenberg FA, Lenssen T, Knipschild PG: The prognosis of ankle sprains. *Int J Sports Med* 1997, 18:285-289.
- [6] Beynnon BD, Renstrom PA, Alosa DM, Baumhauer JF, Vacek PM. Ankle ligament injury risk factors: A prospective study of college athletes. *J Orthop Res.* 2001;19(2): 213-20.
- [7] Gerber JP, Williams GN, Scoville CR, et al. Persistent disability with ankle sprains: a prospective examination of an athletic population. *Foot Ankle Int* 1998;19(10):653-660.
- [8] McKay GD, et al. Ankle injuries in basketball: injury rate and risk factors. *Br J Sports Med* 2001;35:103-108.
- [9] Bosien W R, Staples O S, Russell S W. Residual disability following acute ankle sprains. *J Bone Joint Surg Am.* 1955;37:1237-1243.
- [10] Tropp H, Odenrick P, Gillquist J. Stabilometry recordings in functional and mechanical instability of the ankle joint. *Int J Sports Med.* 1985;6:180-182.
- [11] Freeman M.A. Instability of the foot after injuries to the lateral ligament of the ankle. *J Bone Joint Surg Br.* 1965;47(4):669-677.
- [12] Vaes PH, Duquet W, Casteleyn PP, Handelberg F, Opdecam P. Static and dynamic roentgenographic analysis of ankle stability in braced and nonbraced stable and functionally unstable ankles. *Am J Sports Med.* 1998;26:692-702.
- [13] Carl G. Mattacola et al. Rehabilitation of the Ankle After Acute Sprain or Chronic Instability. *J Athl Train.* 2002 Oct-Dec; 37(4): 413-429.
- [14] Functional Balance Training by Douglas Brooks.
- [15] Thomas B. Michell et al. Functional Balance Training, With or Without Exercise Sandals, for Subjects With Stable or Unstable Ankles. *Journal of Athletic Training* 2006;41(4):393-398.

- [16] May Arna Risberg, P7; Ph D Marianne Msrk, PTZ Hanne Krogstad Jenssen, PTZ, Inger Holm, P7; PhD3 / Orthop Sports Phys Ther 200 1;3 1 :620-63 1 .
- [17] Alyson Filipa et al. Neuromuscular Training Improves Performance on the Star Excursion Balance Test in Young Female Athletes J Orthop Sports Phys Ther 2010;40(9):551-558. doi:10.2519/jospt.2010.3325.
- [18] Hertel J, Miller SJ, Denegar CR. Intratester and intertester reliability during the star excursion balance tests. J Sport Rehabil. 2000;9:104-116.
- [19] Jeremiah O'Driscoll et al. Neuromuscular training to enhance sensorimotor and functional deficits in subjects with chronic ankle instability: A systematic review and best evidence synthesis. Sports Medicine, Arthroscopy, Rehabilitation, Therapy & Technology 2011,3:19 doi:10.1186/1758-2555-3-19.
- [20] McKeon PO, Ingersoll CD, Kerrigan DC, Saliba E, Bennett BC, Hertel J. Balance training improves function and postural control in those with chronic ankle instability. Med Sci Sports Exerc. 2008;40(10):1810-1819.
- [21] Richard C. Clark. Associations between three clinical assessment tools for postural stability. North American Journal of Sports Physical Therapy | Volume 5, Number 3: September 2010: Page 122-130
- [22] Thomas B. Michell\*; Scott E. Ross†; J. Troy Blackburn‡; Christopher J. Hirth‡; Kevin M. Guskiewicz‡ Journal of Athletic Training 2006;41(4):393-398
- [23] Osborne MD, Chou LS, Laskowski ER, Smith J, Kaufman KR. The effect of ankle disk training on muscle reaction time in subjects with a history of ankle sprain. Am J Sports Med. 2001;29:627-632.
- [24] Eils E, Rosenbaum D. A multi-station proprioception exercise program in patients with ankle instability. Med Sci Sports Exerc. 2001;33:1991-1998.
- [25] Rothermel S, Hale S, Hertel J, Denegar C. Effect of active foot positioning on the outcome of a balance training program. Phys Ther Sports. 2004;5:98-103.
- [26] David G. Behm. The use of instability to train the core musculature. Appl. Physiol. Nutr. Metab. 35: 91-108 (2010).
- [27] Robinson R, Gribble P. Kinematic predictors of performance on the Star Excursion Balance Test. J Sport Rehabil. 2008;17:347-357.
- [28] Earl JE, Hertel J. Lower-extremity muscle activation during the star excursion balance tests. J Sport Rehabil. 2001;10:93-104.
- [29] Thorpe JL, Ebersole KT. Unilateral balance performance in female collegiate soccer athletes. J Strength Cond Res. 2008;22:1429-1433. <http://dx.doi.org/10.1519/JSC.0b013e31818202db>.
- [30] Rozzi SL, Lephart SM, Sterner R, Kuligowski L: Balance training for persons with functionally unstable ankles. J Orthop Sports Phys Ther 1999, 29:478-486.
- [31] Ekstrand J, Gillquist J. Soccer injuries and their mechanisms: a prospective study. Med Sci Sports Exerc 1983;15(3):267-270

## Author Profile



**Dr Priyanka Chugh (PT)** is Assistant Professor in Banarsidas Chandiwala Institute of Physiotherapy, Kalkaji, New Delhi, Affiliated to Guru Gobind Singh Indraprastha University, Delhi.



**Dr Tabish Fahim (PT)** is Assistant Professor in Noida International University, Noida, Uttar Pradesh, India