

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 ± 1.54 and 85.46 ± 7.10 respectively, and for FBT group was 23.33 ± 1.58 and 86.66 ± 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)

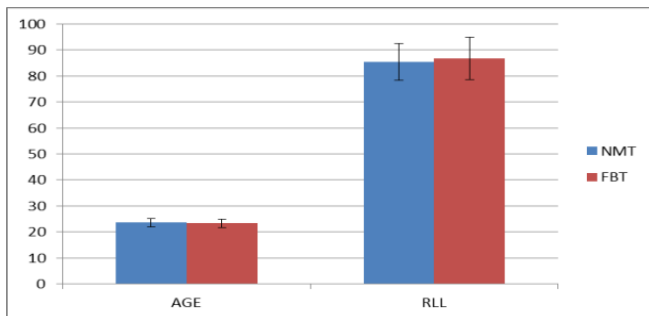


Figure 1

Between group comparison of SLST

Mean and SD of pretest SLST of right leg and left leg in NMT group was 15.04 ± 6.83 and 14.82 ± 7.10 respectively, and in FBT group was 13.44 ± 5.79 and 15.31 ± 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 ± 6.18 and 22.52 ± 6.07 respectively, and in FBT group was 20.3 ± 4.75 and 21.95 ± 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

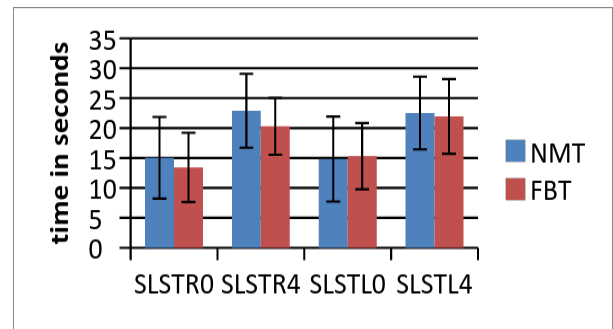


Figure 2

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 ± 6.83 and 22.89 ± 6.18 respectively, and in left leg was 14.82 ± 7.10 and 22.52 ± 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

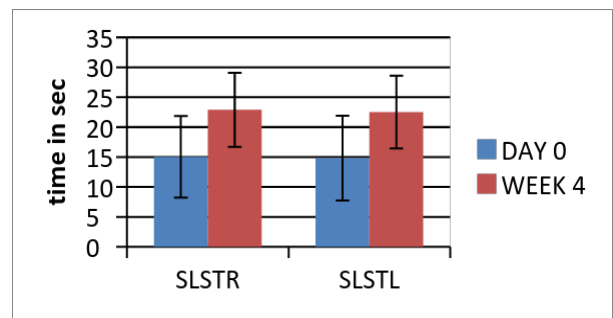


Figure 3

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 ± 5.79 and 20.3 ± 4.75 respectively, and in left leg was 15.31 ± 5.54 and 21.95 ± 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

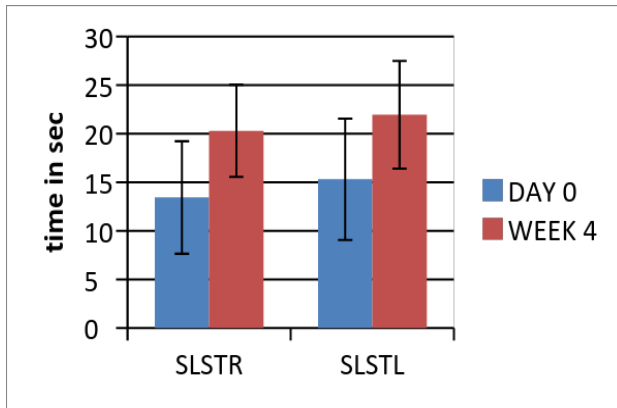


Figure 4

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.²² 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.^{22,25} 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.^{22,25} 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.²⁶ 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).²⁶ 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.³⁰

In our study 73.33% subjects suffered from functional ankle instability in their dominant leg. Ekstrand and Gillquist³¹ found that the dominant leg sustained significantly more ankle injuries than the non-dominant side in male soccer players. But, Beynnon et al⁶ 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

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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