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To Compare the Effectiveness of Intrinsic Foot Muscle Strength Training Versus Balance Training in Reducing Navicular Drop and Ankle Instability on Prolongeed Standing Workers with Excessive Pronation of Foot: A Experimental Study

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Abstract: ***Prolong standing workers having the common issue of pronated foot in standing and while walking, obese and other lifestyle habits also a major cause for pronated foot in people. This may lead to incorrect posture and knee pain, balance issues later. Thirty subjects of prolong standing workers with visible pronated foot and tested navicular drop were randomized into two groups – group A (Intrinsic foot muscle strength training) and group B (Balance training). Outcome measurements of treatment with relative parameters such as Navicular drop test and Cumberland ankle instability test (CAIT). Each group contain 15 subjects. Duration of the study is 4 weeks. There is significant difference between two treatments (A and B) in terms of average increment in LEFT CAIT SCORE (t = 6.08, p = 0.000 < 0.05). In addition, the mean increment in LEFT CAIT SCORE by Treatment A (3.93) is greater than that of Treatment B (1.00). Hence, we conclude that Treatment A (Intrinsic foot muscle strength training) is effective than Treatment B (Balance training) in terms of average increment in LEFT CAIT SCORE.***

Keywords: CAIT score, Navicular drop, Pronated foot, Prolong standing workers, Intrinsic foot strengthening exercises, Balance exercises

1. Introduction

Ankle sprain and instability are the highest case of incidence in recent fastmoving lifestyle. Looking at studies on lower extremity injuries, ankle sprains have the highest incidences, making up to 75% of all lower extremities.

Of ankle sprains, an inversion sprain was reported to account for more than 85% and with the addition of excessive ankle pronation causes the calcaneum to tilt medially compared to normal, producing an unstable position, which may eventually lead to lower extremity injuries and falls.

Prolonged standing causes many abnormal changes in bony structures and ligaments of lower limb especially foot.

In foot subtalar joint plays a significant role in force absorption and therefore most of the studies looking dysfunction of foot found with increased foot pronation that involves calcaneal eversion, a downward migration of the midfoot, then forefoot abduction and dorsiflexion whereas as in supination the calcaneus inverts forefoot adducts and plantar flexes1.

During stance, the foot must be able to adapt to the Transition to a rigid lever to propel the body forward during push off.

In both midfoot and hindfoot the arches play a vital role in weight bearing activities. The flattening of those arches results in various deformities and condition.

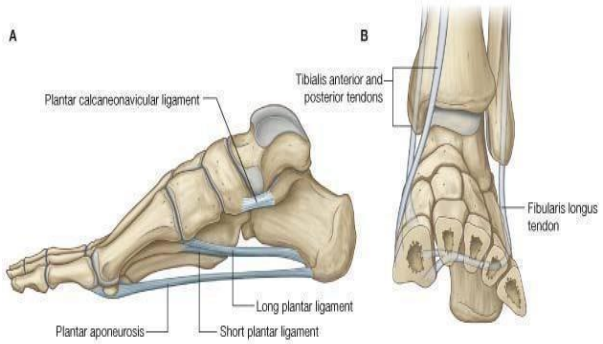


Figure 1: Ligaments involved in medial longitudinal arch

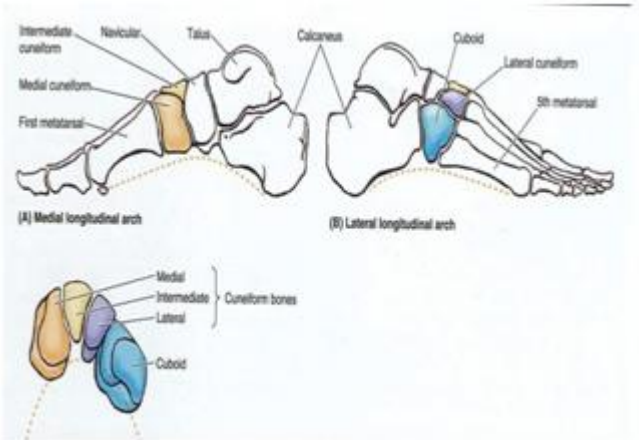


Figure 2: Bones participating in medial longitudinal arch

Excessive pronation is characteristics by a flattening of the medial longitudinal arch and a hypermobile midfoot but may also place greater demands on the neuromuscular system to stabilize the foot and maintain upright stance.

Poor foot position sense is thought to hinder accommodation between the plantar surface of the foot and the support surface, thus requiring postural adjustments and more proximally to maintain upright posture and balance2.

The medial longitudinal arch is made up of the calcaneus, navicular, talus, first three cuneiforms, and first, second, and third metatarsals. It is supported by the soft tissues of the spring ligament (plantar calcanea navicular ligament), deltoid ligament, posterior tibial tendon, plantar aponeurosis, and flexor hallucis longus.

Dysfunction of any portion of the medial longitudinal arch may result in acquired pes planus. The main factors that contribute to an acquired flat foot deformity are excessive tension in the triceps surae, obesity, posterior tibial tendon dysfunction, or ligamentous laxity in the spring ligament, plantar fascia, or other supporting plantar ligaments. It may also result from a tight Achilles tendon or calf muscle.

The medial arch flattening also leads to the loss of stability and gait in normal walking. The excessive pronation of midfoot takes place and loss of proprioception takes place it inhibits the comfort walking and position of ankle.

During the stance phase, the medial longitudinal arch of the foot lowers slightly as the loading of body weight progressively increases. During the first 30-35% of the gait cycle, the STJ pronates, which increases flexibility of the midfoot in order to absorb the stress from weight bearing and protect the foot.

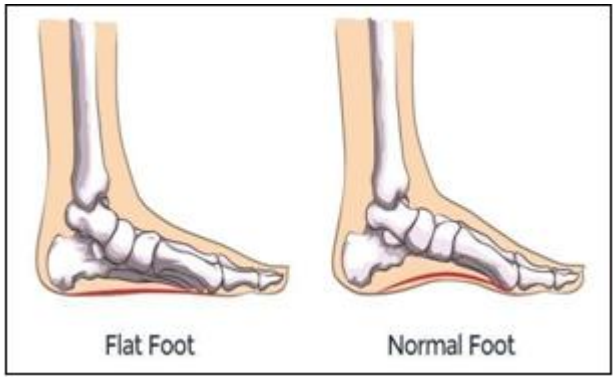


Figure 3: Normal foot and flat foot

So prolong standing workers are being affected due to continuous weight bearing on the stance phase as for occupations related activity. And even individuals with obese overweight are affected at MLA of ankle. The complications of the flattening of MLA are as follows.

- Plantar fasciitis
- Patellofemoral pain
- Foot pain
- Achilles tendonitis
- Hammer toes
- Bunion toes
- Alignment of body in walking, running which causes pain in hip, knee, lower back areas.

Need of the study

Excessive pronated feet is an commonly observed type of condition in prolonged standing workers, the pronated feet leads to the navicular drop and reduced stability over the ankle which results in the reduction in proprioception of ankle joint and even more complications in future such as medial osteoarthritis of knee joint, patellofemoral pain etc. Intrinsic muscle training is most effective training method of improving the arch by maintaining the position of ankle in arched with non-weight bearing followed by weight bearing.

Objectives of the study

- To study the effectiveness of intrinsic foot muscle strength training on navicular drop and ankle stability in individuals with excessive pronated foot
- To study the effectiveness of balance training on navicular drop and ankle stability in individuals with excessive pronated foot.
- To compare the effectiveness of Intrinsic foot muscle strength training versus balance training on navicular drop and ankle stability in individuals with excessive pronated foot.

Hypothesis

- **Null Hypothesis**: There is no significant difference between treatment **A** Intrinsic muscle strength training and treatment **B** balance training in navicular drop and ankle stability on prolonged standing workers accompanied with excessive pronated feet.
- **Experimental Hypothesis**: There is significant difference between treatment **A** Intrinsic muscle strength training and treatment **B** balance training in navicular drop and ankle stability on prolonged standing workers accompanied with excessive pronated feet.

2. Design and Methodology

Subjects

Subjects were selected based on the inclusion criteria and baseline assessment. Inclusion criteria limitations are age within 20 to 45 and BMI ranges from normal to obese.

Baseline assessment includes Achilles tendon position and reduced range of motion of ankle eversion and inversion with flattened medial arch while standing with accompanied excessive pronation of ankle.

All subjects were got detailed explanation about the study and get consent form signed before the study period start. Subjects were randomly selected from find out the changes in height of the navicular and ankle instability of the 30 selected subjects before and after the experiment and men and women were divided equally to the groups.

Study Design

Outpatient department of Jaya college of physiotherapy

Study Setting

Schools and college setup

Source of Data

Data will be collected from the samples refered from Jaya

College of physiotherapy, secondary school teachers, primary school teachers, Chennai. only subjects who were diagnosed as excessive pronated feet will be included in the study. subjects will be selected based on the inclusion criteria.

Sampling Size
Total of 30 samples
- Group A 15samples
- Group B 15 samples

Sample Setting
- Group A 15 samples - intrinsic foot muscle strength training
- Group B 15 samples - balance training

Sampling Criteria:

Inclusion Criteria:
- Subjects involving prolong standing worktime more than 4hours
- Age: 21 to 55 years
- Gender: Both male and female
- BMI: 19 to 35
- Navicular drop: difference greater than or equal to 10 mm

Exclusion Criteria:
- Lower limb fractures
- Recent surgeries
- traumatic injury in past 6 months in lower extremity
- Had any disorder in vestibular, visual centers
- Presence of plantar fasciitis, calcaneal bursitis, and open bleed.

Materials Used:
- Digital Vernier caliper
- Arm chair
- Spongy ball
- Towel
- Stop watch

3. Methodology

A total of 30 subjects referred from Jaya College of physiotherapy, secondary school teachers, primary school teachers, Chennai.

The subjects are selected with age of 21 to 55 years.

They are selected based on the inclusion and exclusion criteria.

The purpose of the study was explained to all 30 subjects and informed consent was obtained from each subject.

All subjects were assessed using a special Performa. Subjects were randomly assigned into either of Intrinsic muscle training (Group A) or Balance training (Group B).

4. Outcome Measurement

Ankle instability
In order to assess for ankle instability of chronic ankle sprain patients, the CAIT (sensitivity: 82.9%, specificity: 74.7%) was used. The CAIT consists of a total of 9 questions which relate to ankle instability of the environment. Five question consists of a score of 0?4, two instability perception questions consists of a score of 0?4, one pain-related question consists of a score of 0?5 and another question consist of a score of 0?2. Based on the perfect score of 30, more than 28 points indicates stability of the ankles while less than 24 points indicate instability. Higher scores indicate normal ankle conditions while lower scores indicate poor stability.

Navicular drop test
The Navicular drop test (NDT) is a highly reliable test method with and intraclass correlation coefficient of 0.971 and serves as a highly valuable measurement method that can determine injury and weakness of the musculoskeletal system that may cause changes in the MLA height. The NDT measures the height of the navicular from the bottom in a non-weight-bearing state and in a relaxed position and then subsequently determines the degree of pronation of the feet by measuring the navicular height again while bearing weight. If there is a difference of more than 10mm, it is diagnosed as foot pronation. The method allows the subject to comfortably sit in a chair and flex his knees at 90°. Then, the knee of foot and 2nd phalangeal is to be measured in a straight line. The tester should hold the talus by hand and adjust the subtalar joint to a neutral posture and another tester should palpate and mark the tubercle of the navicular located approximately 1.5 inch in the lower front of the lower extremity malleolus. After placing Vernier caliper to be horizontal to the ground, we place the point of caliper on the marked navicular tubercle. Points were noted which shown on the digital to measure the height from the ground to the navicular tuberosity. Then, subjects were asked to stand and maintain a gap of the calcaneus by 10 cm and then the height of the navicular tuberosity was measured in a comfortably weight-bearing position with both feet barefooted and placed side by side in the same method as in the sitting position. Differences in the measured values during sitting and standing position were used. Measurements were repeated 3 times to develop a mean value and tests were conducted a total of 2 times for pre-test and post-test assessment purposes.

Figure 11: Measurement of navicular drop in sitting and standing.

Intervention Procedure:

Balance Exercise Training

1) The WEBB program in the current study was performed three times per week for four weeks.
2) The program consisted of a warm-up exercise, standing with a decreased base exercise, graded reaching in standing, and walking practice.
3) No rest period was given between each trial but a rest period of 10 seconds was given between each exercise.
4) Warmup exercise was done at the beginning of the program for three minutes by high stepping on a step of 24 cm height.
5) The participants were asked to ascend the step maintaining their static balance for10 sec, then descend and do the same with the other leg for five repetitions in each limb.
6) Standing with a decreased base exercise was performed bilaterally with the following graduations.
   - Feet together and leveled
   - Semi-tandem stance
   - Tandem stance
   - Single limb stance on the affected leg.

At each graduation, no activity was required to be done except maintaining static balance for one minute. Repetitions increased gradually from 10, 12, 15 to 20 repetitions throughout the four weeks of balance training. The graduation of exercise was done by increasing the repetitions, from 10 in the first week to 12 in the second week and from 12 in the second week to 15 in the third week and so on, but not by increasing the time of exercise Graded reaching in standing exercise was performed by standing on the affected leg then moving the extended arm in forward, sideward, and backward directions. Each participant was asked to maintain this position for one minute in each direction.

Walking practice exercise was done by asking participants to walk 3.5 m stepping over obstacles (cones) of 20 cm height in forward, sideward, and backward directions, initiating the steps and Balance training program stepping through the cones with the affected leg.

The distance between each two successive cones was 50cm. Repetitions of this exercise increased gradually from 10, 12, 15 to 20 repetitions throughout the four weeks of training.

Figure 13: Subjects performing semi tandem

Figure 14: Subjects performing tandem stance

Figure 15: Subjects performing single leg stance

Intrinsic Foot Muscle Strength Training Exercises:

1) The SFE is accomplished by shortening the foot in an antero-posterior direction and actively attempting to bring the head of the first metatarsal toward the heel without toe flexion.

2) TCE is achieved by curling the toes on a towel, bunching the towel beneath the foot using interphalangeal and metatarsophalangeal flexion of the toes.
3) In order to minimize error values and increase objectivity, a stopwatch was used to measure exercise times.
4) The exercise was carried out in a sitting position without weights for 2 weeks and in a standing position with weights for 3rd and 4th weeks.
5) The exercises were performed 3 times per week, with three sets performed in one week totaling up to 20 to 25 times, and with 5 minutes spent per set.

Gender	Frequency	Percentage
Male	11	37
Female	19	63
Total	30	100

5. Data Analysis and Statistics

Statistical Methodology

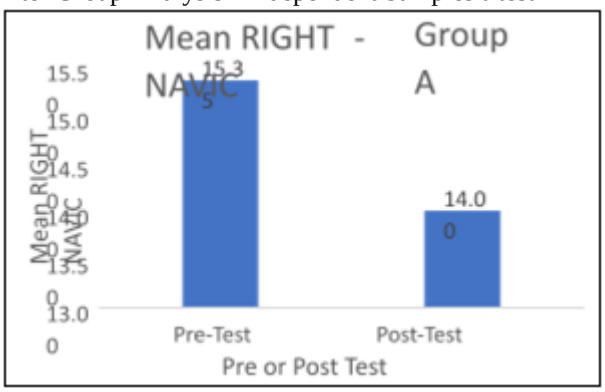
Descriptive Statistics

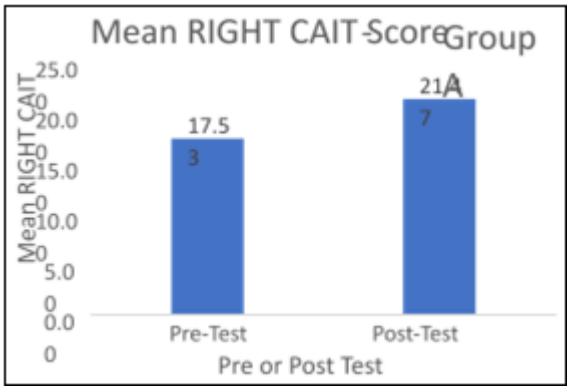
	Age	Height	Weight	BMI
Count	30	30	30	30
Min	27	137	40	20
Max	54	178	87	34.7
Mean	40.40	155.50	62.70	26.08
SD	8.96	11.63	11.56	4.22

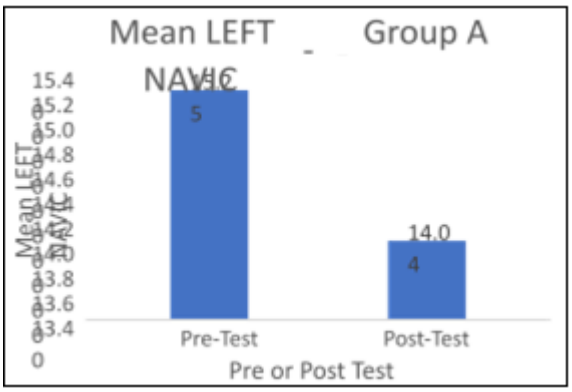
- Mean & Standard deviation for Continuous variables, namely AGE, HEIGHT, WEIGHT, BMI, NAVICULAR DROP and CAIT SCORE

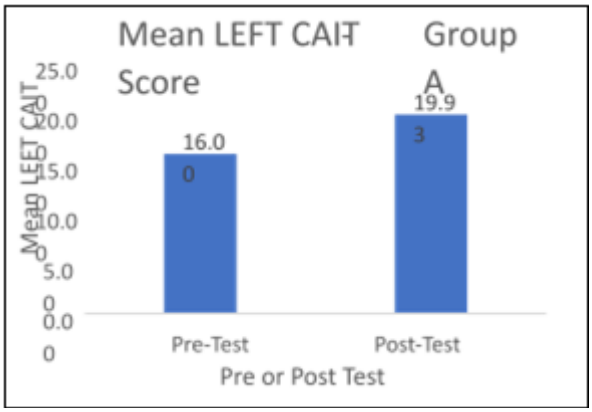
Inferential Statistics

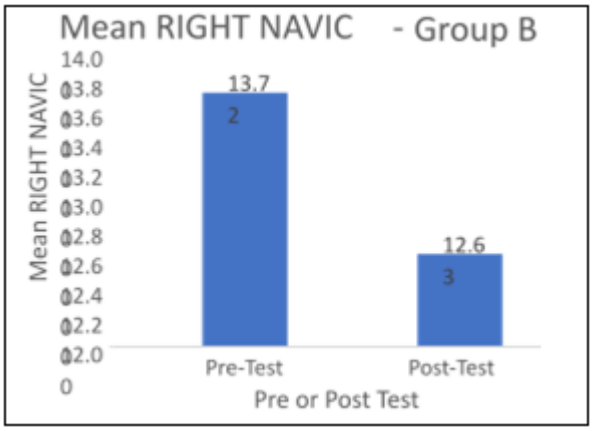
- Intra Group Analysis - Paired Samples t-test
- Inter Group Analysis - Independent Samples t-test

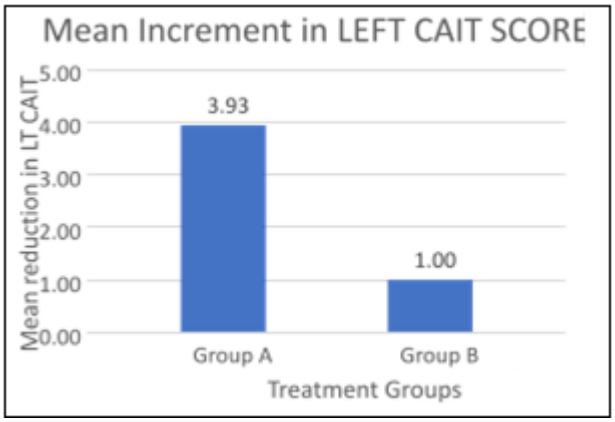


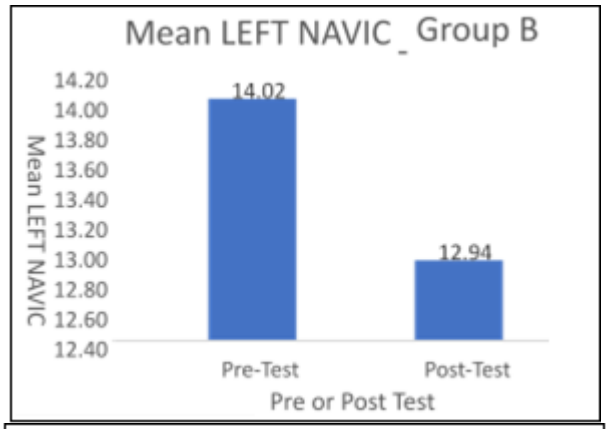


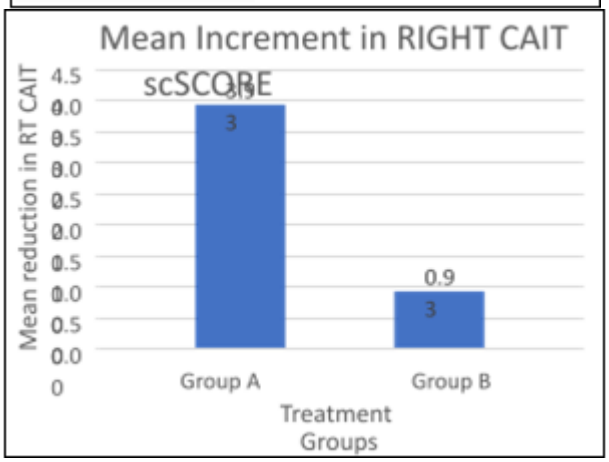


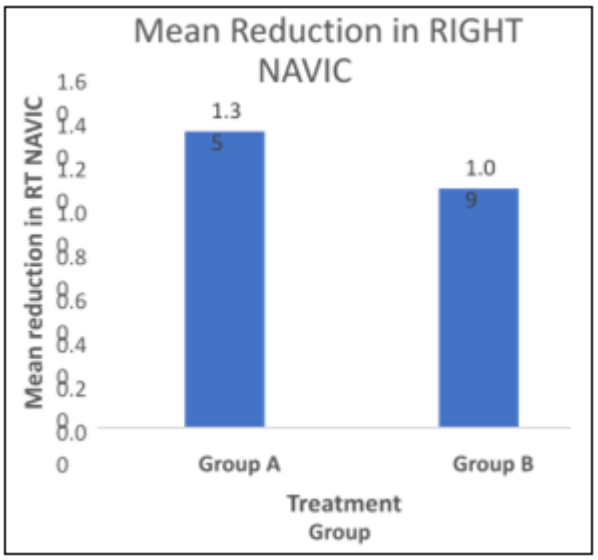












There is **significant difference** between two treatments (A and B) in terms of **average increment** in LEFT CAIT SCORE ($t = 6.08$, $p = 0.000 < 0.05$). In addition, the mean increment in LEFT CAIT SCORE by Treatment A (3.93) is greater than that of Treatment B (1.00). Hence, we conclude that Treatment A is **effective** than Treatment B in terms of average increment in LEFT CAIT SCORE.

6. Discussion

Due to flatfoot and excessive foot pronation, the ankle position sense decreases gradually. In order to correct the posture or foot pronation several studies have been carried out. **Pooja saikia** presented that 8 weeks of intrinsic muscle strengthening exercises is more effective than conventional physiotherapy exercises in reducing navicular drop in prolonged standing workers. **Kyoung A Chung** presented that intrinsic muscle strength training is the effective way to correct foot pronation. **Ryoko Suzuki** presented that a 6week program of simple one-leg standing and a unilateral heel raise exercises can positively affect navicular drop height and balance ability in subjects with excessive pronated feet. **Noha Mahmoud Youssef** presented that unilateral balance training have positive effects on postural control in peoples with chronic ankle instability.

The main aim of the study to find the effective way to reduce navicular drop and balance disability in people with excessive pronated feet.

In this study we compare the intrinsic muscle strength training and balance training in reducing navicular drop and ankle instability on prolonged standing workers.

In this study totally 30 samples were assessed and based on inclusion criteria samples were selected and randomly divided into two groups. Group A (intrinsic foot muscle strength training) and Group B (balance training).

Intrinsic muscle strength training focuses only on the intrinsic muscles whereas balance training focuses both intrinsic muscles and calf muscles, extrinsic muscles.

There is significant difference between two treatment groups in terms of average increment in left and right CAIT scores. In addition, the mean increment in left and right CAIT scores by treatment Group A (3.93) is greater than of treatment Group B (1.00).

The results of this study show that when comparing within the group there was significant improvement in the pre and post test measurement of both the groups. But comparing between the groups the results shows that there is no statistically significant difference between (Group A) intrinsic foot muscle strength training vs (Group B) balance training, but there was a difference in mean is observed between the groups.

The result shows that the mean of Group A is higher than the Group B in terms of increasing CAIT scores.

Kyoung A chung, eunsang11 lee states that short foot exercises are more effective in providing intrinsic foot

muscle training for patients with pronated feet, furthermore short foot exercises may be used to provide ankle stability.

Ryoko suzuki states that a 6 week program of simple one leg standing and unilateral heel raise exercises can positively affect navicular drop height and balance ability in subjects with excessive pronated feet. **Noha Mohamed youssef5** Both WEBB program and unilateral balance training have positive effects on postural control in female CAI.

When summarizing the findings of previous studies and for this study, it can be seen that both intrinsic foot muscle strength training and balance training are effective in reducing medial longitudinal arch in excessive pronated foot. Thus, previous researches support this study.

According to experimental results, both intrinsic foot muscle strength training and balance training are effective in navicular drop, but intrinsic foot muscle training is more effective than balance training in CAIT score results. Based on these findings, the structure of medial longitudinal arch undergo effective changes for patients with foot pronation through effective intrinsic foot muscle strength training

7. Conclusion

The study suggests that both the treatments are individually effective in reducing navicular drop and increasing CAIT scores from pre-test to post test. By comparing the efficacy of the two treatments in terms of two measures Navicular drop test and CAIT score, we found that both the treatment is equally effective in terms of reduction in NDT test and increment in CAIT score.

From the mean difference in the statistical analysis, concluded that intrinsic foot muscle strength training has the highest efficacy to treat the navicular drop and ankle instability of prolong standing workers accompanied with excessive pronation of feet. Hence, intrinsic foot muscle strength training improved the stability and reduced navicular drop height as of statistical analysis report.

References

[1] POOJA SAIKIA (2015); Effectiveness of intrinsic muscle strengthening with orthosis over conventional physiotherapy with orthosis for navicular drop in prolong standing workers.
[2] KAREN P. COTE (2005); effects of pronated and supinated foot postures on static and dynamic postural stability.
[3] MUELLER MJ HOST JV, MORTAN BJ (1993); Navicular drop as a composite measure of excessive pronation
[4] DONG-CHUL MOON (2013); Immediate effect of short foot exercise on dynamic balance of subjects with excessive pronated feet.
[5] NOHA MAHMOUD YOUSSEF, AZZA MOHAMMED ABDELMOHSEN (2018): effects of different balance training programs on postural control in chronic ankle instability: a randomized trial.
[6] SUSAN L ROZZI, SCOTT M. LEPHART (1999); Balance training for persons with functionally unstable ankles.
[7] Claire E. hiller, MAppSc, kathrayn M. (2006): a report of validating and reliability testing of Cumberland ankle instability tool.
[8] BALOGUN JA, ADESINASI CO, MARZOUK DK. (1992): The effects of a wobble board exercise training program on static balance performance and strength of lower extremity muscle. Riley PO, Mann RW, Hodge WA. Modelling of the biomechanics of posture and balance. J Biomech.1990.
[9] Steven D. Stovitz M. D. Hyper pronation and foot pain. Journal of the Physician and sports medicine.2004; 32 (8): 19-26.
[10] Balint GP, Kordo J, Hangody L. Regional Musculoskeletal conditions foot and ankle disorders. Best practioner Res Clin Rheumatoid.2003; 17 (1): 87-111.
[11] Kyoung A Chung, eunsang lee, seungwon lee (2016): Effect of intrinsic foot muscles training on medial longitudinal arch and ankle stability in patients with chronic ankle sprain accompanied by foot pronation.
[12] Snow RE, Williams KR. High heeled shoes their effect on center of mass position, posture, their dimensional kinematics rearfoot motion and ground reaction forces. Arch Phys Med Rehab.1994; 75 (5): 568-576.
[13] Gill LH. Planter fasciitis: diagnosis and conservative management. J. Am Acad Orthop surg. 1997; 5 (2): 109-117.
[14] Bahram Jam, Mephty. Evaluation and Retraining of intrinsic foot muscles for pain syndromes related to abnormal control of pronation.
[15] Brody DM, techniques in evaluation and treatment of injured runner. Orthop Clin north Am. 1982; 13 (3): 541-55.
[16] Pawell M, Post WR Keener J. Effective treatment of chronic planter fasciitis with dorsiflexion night splints: a crossover perspective randomized clinical trial. Foot Ankle Int.1998; 19 (1): 10-8.
[17] Bill Vicezino. Orthotics in treatment of lower limb conditions: musculoskeletal physiotherapy perspective. manual therapy.2004; 9 (4): 185-196.
[18] Koren P. Cote. Effect of pronated and supinated foot postures on static and dynamic postural stability. Journal of Atheletic training, J. Athelete train.2005; 40 (1); 41-46.
[19] Pamela, K Levangia, Cynthia C. Norkin joint structure and function.5th edition; 2011.
[20] Jason, E Bennett, Mark F. Rinking, Mitchell. J. Rauh relationship between isotonic planter flexor endurance, navicular drop and exercise related leg pain in a cohort of collegiate cross country runners. Int. J. sports physical therapy.2012; 7 (3): 267-278.
[21] S. C. Morrison, BR Durword GF Watt MDC Donaldsport A literature review evaluating role of navicular in clinical and the scientific examination of foot. British journal of Podiatry.2004; 7 (4): 110-114.
[22] Sabrina Jayne Charleswartch and Stina Magistad Johansen. Navicular Drop Test 2010.
[23] Mueller MJ Host JV, Mortan BJ, Navicular drop as a composite measure of excessive pronation. American Academy of paedetrics.1993; 83 (4): 198-202.
[24] Rasmus G Nielsen, Michael S Rathleff, Ole H Simonsen and Henning Langberg. Determination of

normal values for navicular drop during walking: a new model correcting for foot length and gender. Journal of foot and Ankle Research.2009, 2; 12.
[25] Ann Vinicombe, Anita Raspovic, Hylton B. Menz. Reliability of Navicular Displacement Measurement as a Clinical Indicator of Foot.
[26] Tiberio D. Pathomechanics of structural foot deformities. Phys Ther.1988; 68: 1840- 1849.
[27] Neely FG. Biomechanical risk factors for exercise-related lower limb injuries. Sports Med.1998; 26: 395-413.
[28] Guskiewicz KM, Perrin DH. Research and clinical applications of assessing balance. J Sport Rehabil. 1996; 5: 45-63.
[29] Alexander KM, La Pier TL. Differences in static balance and weight distribution between normal subjects and subjects with chronic unilateral low back pain. J Orthop Sports Phys Ther.1998; 28: 378- 383.
[30] Riley PO, Mann RW, Hodge WA. Modelling of the biomechanics of posture and balance. J Biomech 1990; 23: 503-506.
[31] Nashner LM, Black FO, Wall C., III. Adaptation to altered support and visual conditions during stance: patients with vestibular deficits. J Neurosci.1982; 2: 536- 544. Shumway-Cook A, Horak FB. Assessing the influence of sensory interaction of balance. Phys Ther.1986; 66: 1548-1550; .
[32] Janda, v, and VaVrova, M (1996). Sensory motor stimulation. Baltimore: Williams & wilkins, pp.319-28