ORIGINAL RESEARCH

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EFFECTIVENESS OF INTRINSIC MUSCLE STRENGTHENING WITH ORTHOSIS OVER CONVENTIONAL PHYSIOTHERAPY WITH ORTHOSIS FOR NAVICULAR DROP IN PROLONG STANDING WORKERS

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ABSTRACT

Background and Objective: Foot pronation is a series of movements which is intended to absorb shock by decelerating and cushioning the foot as it comes in contact with surface. When this motion is exaggerated, the ankle rolls too far inward and the arch is flattened causing overpronation. It is seen that with an abnormal pronation, navicular drop occurs. Navicular drop causes pain in ankle and knee, fatigue, difficulty in walking. The purpose of the study was to determine the effect of intrinsic muscle strengthening with orthosis over conventional physiotherapy exercises with orthosis for correction of navicular drop and Pain Disability in prolong standing workers.

Method: An Experimental study design, seventy industrial workers were tested for navicular drop test out of which fifty tested positive. The subjects were divided into two groups Group A (N = 25) and Group B (N = 25). Group-A subjects received intrinsic muscle strengthening exercises with orthosis and Group-B received conventional physiotherapy exercises with orthosis. The duration of treatment continued was given for 8 weeks and outcome measurements were measured at 0 day, 4th week and 8th week using the Navicular drop (ND) test and Pain Disability Questionnaire (PDQ).

Results: Comparative analysis using Independent t-test was carried out separately for ND and PDQ. For ND, t = -5.01 which is highly significant (p = 0.00). It has been inferred that ND decreases more when intrinsic muscle strengthening with orthosis was applied. To see the difference of means of PDQ, t = -1.97 which is significant (p = 0.049) implying that PDQ decrease more when intrinsic muscle strengthening was applied as compared to conventional physiotherapy with orthosis.

Conclusion: It is concluded that 8 weeks of intrinsic muscle strengthening exercise with orthosis is more effective than conventional physiotherapy exercises with orthosis in reducing navicular drop and improving Pain Disability in prolong standing workers.

Key words: Navicular Drop Test, Foot Pronation, Intrinsic muscle exercise, Pain Disability Questionnaire, foot orthosis, intrinsic muscle strengthening exercises

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INTRODUCTION

Prolonged standing causes many abnormal changes in bony structures and ligament of lower limb especially in foot.[1] In Foot, subtalar joint plays a significant role in force absorption and therefore, most of the studies looking at the dysfunction of the foot found with increased foot pronation[16] that involves calcaneal eversion, a downward migration of the midfoot, then forefoot abduction and dorsiflexion[2] where as in Supination the calcaneus inverts, forefoot adducts and plantar flexes.[1,2]

In standing, the navicular bone maintains its position high on the medial longitudinal arch through the static support of surrounding bones and ligaments.[3] A natural alignment between the talus and the navicular and calcaneonavicular ligament adjoining these bones locks the foot in place.[3] During ambulation, dynamic support from the posterior tibial tendon (PTT) is needed to maintain the superior position of the navicular.[3,4] A weak PTT unable to support the position of the navicular, and, once again, a loss of the medial longitudinal arch may occur.[2,3,4]

Foot pronation is a series of movements which is intended to absorb shock by decelerating and cushioning the foot as is comes in contact with surface. When this motion is exaggerated, the ankle rolls too far inward and the arch is flattened causing overpronation.[5] It is seen that with a abnormal pronation, navicular drop occurs.[5]

Navicular drops defined as the distance between the original height of the navicular from the floor, with the foot on the floor in sitting in the subtalar neutral position, and the final weight-bearing position of the navicular in relaxed stance.[4,6] The navicular drop test was used as an indicator of foot pronation.[6] Navicular drop test addresses the plantar flexion component of talar motion and is used to assess the amount of subtalar pronation.[7]

Intrinsic muscles have a functional role in stabilizing foot during single limb balance.[8] Intrinsic muscles help in maintaining concavity of the foot and help in stabilizing the tarsal and metatarsal bones.[7,8] Fatigue of intrinsic foot muscles causes increase in navicular drop.[6,8,9] These muscles also active during gait and function similar to elastic springs by supporting the medial longitudinal arch and maintaining the concavity of the foot.[10] It is therefore suggested that effective neuromuscular control of the Intrinsic foot muscles is essential in order to stabilize the tarsal and metatarsal bones and modulate the rate of pronation.[10]

Orthoses is a appliance that exerts external forces to support joints, prevent or correct deformities or to improve function of movable parts of body[8,11] Literature review says temporary orthosis have good effect on navicular drop when compared pre and post exercise.[11] Orthotics has got a significant value in treating antipronation and navicular drop.[12] Temporary anti-pronation orthotic with medial footpad is used to determine if a transient correction of abnormal pronation is associated with a marked amelioration of symptoms and function.

Since there is a lack of researches in intrinsic muscles strengthening exercises and orthosis to prevent navicular drop, this study with research question does there is difference in effect of intrinsic muscle strengthening with orthosis compared with conventional physiotherapy with orthosis to prevent navicular drop and improve Pain Disability. Hence, the purpose of this study is to compare the effectiveness between the intrinsic foot muscle strengthening with orthosis and conventional physiotherapy with orthosis to prevent navicular drop and Pain Disability in subjects with prolonged standing work. It was null hypothesized that there will be no significant difference in effect of Intrinsic foot muscle strengthening with orthosis and conventional physiotherapy with orthosis in preventing reduce navicular drop and improving Pain Disability.

METHODOLOGY

An experimental study design with two groups- Group A and Group B. As this study involved human subjects the Ethical Clearance was obtained from the Ethical Committee, Department of Physiotherapy, Assam down town University, Panikhaiti as per the ethical guidelines of Bio-medical research on human subjects. Subjects included in the study were with age group between 35-50 years,[1] both male and female subjects, nature of work involves standing more than 4 hours. Subjects were excluded with oedema, obesity, neurological involvement, History of deformity, surgery.

Subjects were recruited from Assam Roofing Industry, Bonda, Assam the study was conducted in this Industry. 70 industrial workers were asked to go for the navicular drop test out of which 50 were positive included in the study and divided into two equal groups (N = 25) by Simple random sampling method using closed envelops, randomly allocated subjects into two groups. Subjects were informed about the study and a written informed consent was taken.

Procedure of intervention for Group A:- Subjects in this group received Intrinsic foot

muscles strengthening exercise with foot pronation orthotics.

Intrinsic foot muscle strengthening:[9] The subject standing in front of a wall, with the feet shoulder width apart and knees were slightly flexed. The fingertips may be lightly placed touching the wall. In order to increase the height of the medial longitudinal arch, the subject was instructed to gently supinate the feet by lifting all the toes off the floor, then slowly drop the toes down again but maintaining the medial longitudinal arch. This most often results in a rise of the medial longitudinal arch and the navicular bone, due to the windlass effect via the plantar fascia. If this procedure was difficult, then subjects were instructed to increase the height of the medial longitudinal arch by actively attempting to approximate the head of the first metatarsal towards the heel without flexing the toes. While maintaining the medial longitudinal arch, standing on single leg, the subject was asked to be as steady as possible. The fingertips should remain lightly on the wall for balance and fall prevention. The subject was asked to count to 30 seconds and the therapists observe for the steadiness of the navicular height and for any compensatory extrinsic foot muscle activity. The subject was asked to repeat the process on the other lower extremity.

Arch lift:[37] Subject seated in a chair with feet pointing forward, pulls ball of feet and heel towards each other for 5 seconds.

Procedure of intervention for Group B: Subjects in this group received Conventional physiotherapy exercises with foot pronation orthotics.

Conventional physiotherapy includes active movements and isometrics:[13]

a. **The alphabets:** Subject seated keeping the edge of the heel on the floor, draw the alphabets one letter at a time by moving the ankle and using the great toe as the "pen". The subject was asked to do two sets of (A-Z), two to three times a day.
b. **Windshield wiper:** The subject seated with the foot flat on the floor and facing straight ahead, rotates the involved foot to mimic a windshield wiper blade: Pivot the foot outward and touch the inside edge of the foot to the floor. The subject was asked to rotate it inward and touch the outside of the foot to the floor and to do two sets of 10 to15 repetitions, two to three times day.
c. **Seated calf rasie:** The subject seated with the involved foot flat on the floor, asked to lift the heel as far as possible while keeping the toes on the floor. The subject was asked to return the heel to the floor. The subject was asked to do two sets of 10 to 15 repetitions, two to three times a day.
d. **Eversion and inversion isometrics:** The subject in standing place the outside of the one foot against a table leg or door jamb, subject was asked to push outward with the foot for 2 to 3 seconds and to do two sets of 10 to 15 repetitions, two to three times a day.
   Inversion: The subject was asked to stand with the inside of the foot against the table leg or door jamb. The subject was asked to push inward for 2 to 3 seconds and to do two sets of 10 to 15 repetitions, two to three times a day.
e. **Single leg stand:** The subject was asked to stand while placing one hand on a table. The subject was asked to shift some of the weight to the involved foot for 15 seconds. The subject was asked to increase the time spent on the foot by 15 seconds until they can stand for 45 seconds. The subject was asked to gradullay increase the amount of weight supported by the involved foot until full body weight is used. The subject was asked to do two sets of 10 to 15 repetitions, two to three times a day.

Exercise band- eversion and inversion: The subject was asked to sit with the involved leg straight, asked to tie to loop in an elastic exercise band (Theraband) and attach the other end to a heavy abject such as a table leg. The subject was asked to place the loop around the ball of the foot and to rotate (Evert) the foot away from the table leg and return to the starting position. The subject was asked to do not rotate the leg to do exercise and to do two sets of 10 to 15 repetitions, two to three times a day.

Inversion: The subject was asked to reverse the position of the exercise band. The subject was asked to rotate (invert) the foot in ward, away from the table leg. The subject was asked to do two sets of 10 to 15 repetitions, two to three times a day.

Gastrocnemius stretch: The subject was asked to place the injured foot behind the uninvolved foot and keep the back knee straight, with the heel firmly planted on the floor. The subject was asked to lean forward against a wall so that you feel a stretch in the calf farthest from the wall. The subject was asked to hold for 30 seconds. The subject was asked to do two sets of 10 to 15 repetitions, two to three times a day.

Soleus stretch: The subject was asked to stand with the involved foot in front on the other foot. The subject was asked to bend the knee of the back foot

and lower your body toward the floor without letting the back heel rise off the floor. The subject was asked to should feel the stretch in the lower calf of the back leg. The subject was asked to do two sets of 10 to 15 repetitions, two to three times a day.

Figure-1: Measuring the navicular height in neutral (NHN).

Figure-2: Intrinsic muscle training.

Figure-3: Arch lift

Figure-4: Conventional Physiotherapy-ROM exercises

Figure-5: Medial longitudinal arch orthosis.

Outcome Measurements:

Navicular drop test using a ruler and Disability Questionnaire was measured before, at 4th week and after 8 weeks of intervention.

Navicular drop test:[14-19] Subject in sitting position with their feet flat on a firm surface and with the knees flexed to 90^0 and ankle joints in neutral position. The most prominent point of the Navicular tubercle was marked with marker by placing the foot in subtalar neutral position, to achieve subtalar neutral position, the client was asked to perform active extension of toes without raising the metatarsal heads. The toes were then slowly dropped down. Subtalar neutral position was established when talar depressions are equal on medial and lateral side of the ankle. While one assessor maintains subtalar neutral position, another assessor places an index card on the inner aspect of the hindfoot, with the card placed from the floor in a vertical position passing the navicular bone. The level of the most prominent point of the navicular tubercle was marked on the card. Height of navicular tubercle from the floor was then measured with standard ruler and this is called navicular height in neutral (NHN). The second measurement was taken in standing (relaxed calcaneal stance) this is called navicular height in standing (NHS). Navicular drop is measured (NHN-NHS). 6-9 mm is normal and more than 10 mm abnormal.[14-19]

The Pain Disability Questionnaire (PDQ): is an instrument for measuring disability caused by pain. It consist of 15 items, divided into two domains: one measuring the Functional Condition, consisting of nine items (1,2,3,4,5,6,7,12,13); and the other measuring the Psychosocial Component, consisting of six items (8,9,10,11,14,15). The Functional Condition has a maximum score of 90 points, and the psychosocial component a maximum score of 60. The total score of the PDQ, ranging from 0 to 150, is the total of the scores on the two components. The following classification is used to examine the score: mild/moderate (0-70); severe (71-100); and extreme (101-150). Reliability

of the original instrument, assessed through the test retest method, was 0.94 to 0.98. The analysis of internal consistency showed a Cronbach's Alpha coefficient of 0.96.[20,21]

Statistical Methods

Descriptive statistical analysis was carried out in the present study. Out Come measurements analyzed are presented as mean ± SD. Significance is assessed at 5 % level of significance with p value was set at alpha-level of 0.05 less than this is considered as statistically significant difference. Repeated Measures Analysis of Variance (RAMANOVA) and Friedman's ANOVA was used to analysis within the group and Bonferroni's as post-hoc test was used to find the significance in pair-wise comparison. Independent 't' test as a parametric has been used to compare the means at multiple level measurements. The Statistical software namely SPSS windows Version 20.0, Stata 8.0, MedCalc 9.0.1 and Systat 11.0 were used for the analysis of the data and Microsoft word and Excel have been used to generate graphs, tables etc.

RESULTS

The study was conducted on total 50 male subjects (Table-1), in Group A there were 25 subjects with mean age 39.80 years were included in the study. In Group B there were 25 subjects with mean age 40.68 years were included in the study. There is no significant difference in mean ages between the groups.

Analysis within groups for Navicular drop (ND) (Table-2), from ANOVA of Group A, there is significant difference in Navicular drop between points of time of observation (p = 0.00). Post hoc analysis shows that ND decreased significantly from day 0 to the end of 8th week. The value of F to find the difference in ND in Group B is significant (p = 0.00). It has been found in post hoc analysis that ND decreased significantly after application of conventional physiotherapy to the patients after 8th week. In other words, intrinsic muscle strengthening and conventional physiotherapy are effective in decreasing ND.

Analysis within groups for Pain Disability Questionnaire (PDQ) (Table-3), from ANOVA, Group A, value of F is highly significant (p = 0.007), this implies that mean PDQ has decreased significantly after 8 weeks of treating with intrinsic muscle strengthening. On the other hand, it is revealed that there is no significance in mean of PDQ in Group B. Thus conventional physiotherapy is not significantly effective in decreasing PDQ.

Comparative analysis (Table-4) using Independent t-test was performed to compare the effectiveness between intrinsic muscle strengthening and conventional physiotherapy. The tests were carried out separately for ND and PDQ. For ND, t = - 5.01 which is highly significant (p = 0.00). It has been inferred that ND decreases more when intrinsic muscle strengthening was applied. To see the difference of means of PDQ, t = -1.97 which is significant (p = 0.049) implying that PDQ decrease more when intrinsic muscle strengthening was applied as compared to conventional physiotherapy. It can be inferred from above that intrinsic muscle strengthening is more effective than conventional physiotherapy in reducing navicular drop.

Table-1: Demographic information

Group A	Age (Mean ± SD)	39.68 ± 3.827
Group B	Age (Mean ± SD)	40.68 ± 4.00

Graph-1: Mean age of subjects of Group A and Group B

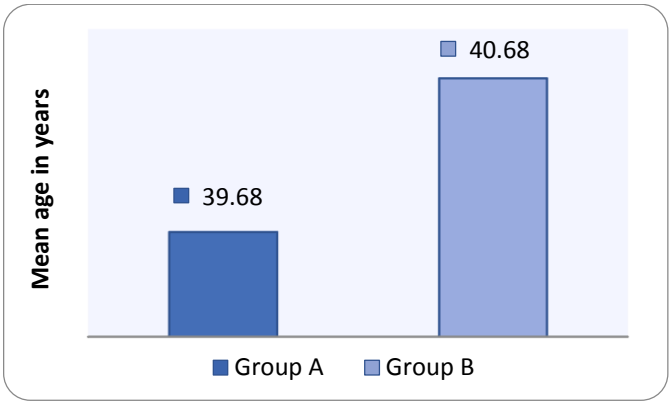

Table-2: Analysis of means Navicular drop in day 0, 4th week and 8th week within Group A and Group B

		Sum of Squares	df	Mean Square	F*	Significance
Group A	Between Groups	192.507	2	96.253	126.83*	0.000**
	Within Groups	54.640	72	0.759		
	Total	247.147	74			
Group B	Between Groups	69.147	2	34.573	22.87*	0.000**
	Within Groups	108.800	72	1.511		
	Total	177.947	74			

*ANOVA for ND ** Statistically Significant difference p < 0.05; NS- Not significant.

Graph-2: Analysis of means Navicular drop in day 0, 4th week and 8th week within Group A and Group B

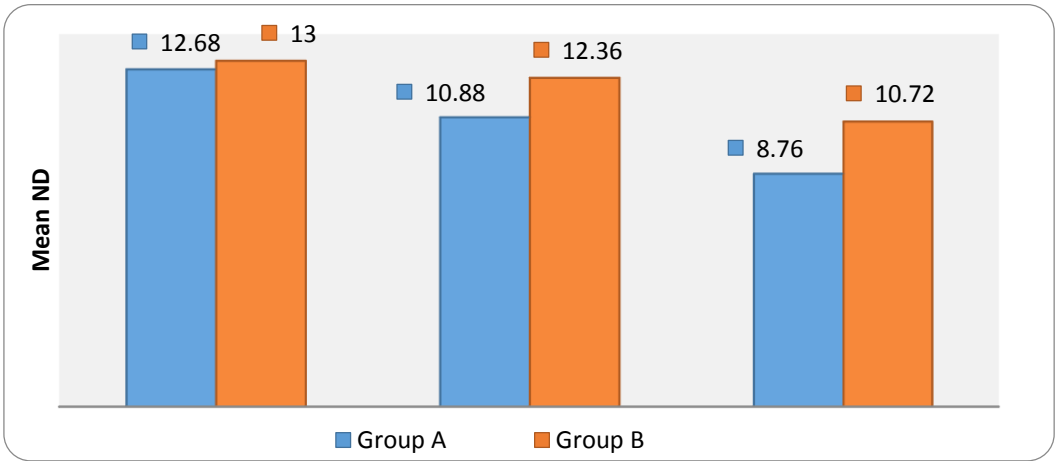

Table 3: Analysis of mean Pain Disability Questionnaire in day 0, 4th week and 8th week within Group A and Group B

		Sum of Squares	df	Mean Square	F*	Sig.
Group A	Between Groups	11.760	2	5.880	5.271	.007**
	Within Groups	80.320	72	1.116		
	Total	92.080	74			
Group B	Between Groups	4.880	2	2.440	2.668	.076 (NS)
	Within Groups	65.840	72	.914		
	Total	70.720	74			

*ANOVA for DQ ** Statistically Significant difference $p < 0.05$; NS- Not significant.

Graph-3: Analysis of mean Pain Disability Questionnaire in day 0, 4th week and 8th week within Group A and Group B

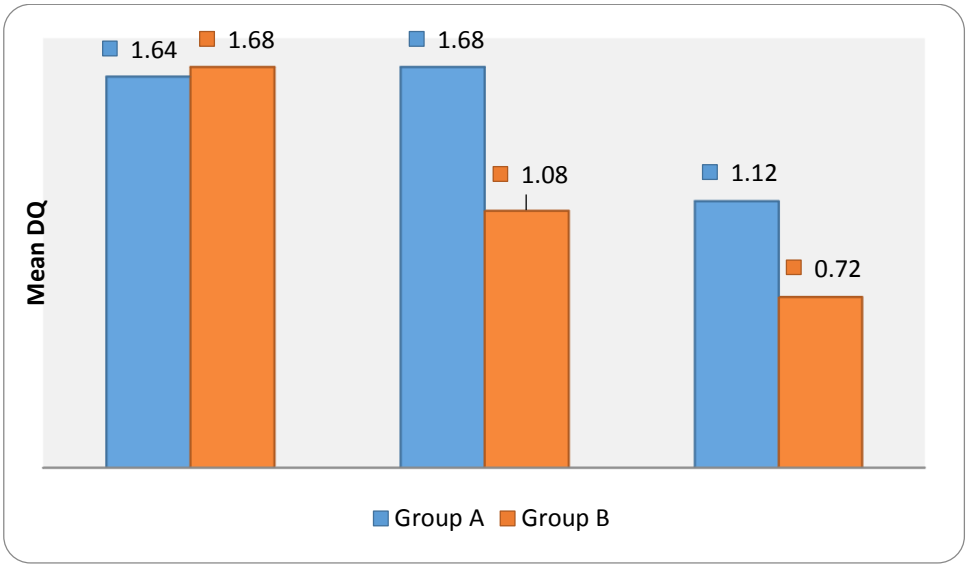

Table-4: Comparative analysis between Group A (intrinsic muscle with orthosis) and Group B (Conventional Physiotherapy with orthosis)

	Treatment	N	Mean ± SD	t	df	p
ND	Intrinsic muscle with orthosis	50	8.76 ± 1.01	-5.01	48	0.00**
	Conventional physiotherapy with orthosis	50	10.72 ± 1.67			
PDQ	Intrinsic muscle with orthosis	50	0.72 ± 1.02	-1.970	48	0.049**
	Conventional physiotherapy with orthosis	50	1.12 ± 1.01			

* Independent 't' test ** Statistically Significant difference $p < 0.05$; NS- Not significant.

DISCUSSION

The comparative study was done to find which treatment improves the Navicular drop correction in prolong standing workers. It is found from analysis that after 8 weeks of treatment ND correction improvement and PDQ decrease more when intrinsic muscle strengthening was applied as compared to conventional physiotherapy. It can be inferred from analysis the intrinsic muscle strengthening is more effective than conventional physiotherapy in reducing navicular drop.

Foot pronation is a series of movements which is intended to absorb shock by decelerating and cushioning the foot as is comes in contact with surface. When this motion is exaggerated, the ankle rolls too far inward and the arch is flattened causing overpronation.[5] It is seen that with a abnormal pronation navicular drop occurs.[5]

In standing, the navicular bone maintains its position high on the medial longitudinal arch through the static support of surrounding bones and ligaments.[3] A natural alignment between the talus and the navicular and a spring ligament (ie, the calcaneonavicular ligament) adjoining these bones locks the foot in place.[3] With ambulation, dynamic support from the posterior tibial tendon (PTT) is needed to maintain the superior position of the navicular.[3,4] A weak PTT is unable to support the position of the navicular, and, once again, a loss of the medial longitudinal arch may occur.[2,3,4] Biomechanically, the precipitating events in hyperpronation can be viewed in relation to the position of the talus.[1] Although kinetic chain reactions occur from the hip down to the foot, the interdependent relationships of the talus, calcaneus, and navicular are especially important.[1] The talus contacts the anterolateral edge of the proximal navicular bone. The talus has no tendinous attachments and thus depends on the static support of surrounding ligaments and bones. Malposition of one bone affects the adjacent proximal or distal bone.[1,2,3] The position of the talus is supported distally by the navicular bone.[3] The position of the calcaneus is greatly determined by the Achilles tendon.[3] The Achilles tendon inserts onto the calcaneus slightly lateral to midline.[3] A tight Achilles provides not only plantar flexion, but also eversion to the calcaneus.[3,4] Both of these actions translate force medially on the talus and downward and medially on the navicular, possibly causing subsequent loss of height of the medial longitudinal arch.[2,3,4]

In Group A, the improvement could be because of intrinsic muscle strengthening and orthotics. Intrinsic muscles have a functional role for stabilizing foot during single limb balance.[8] Intrinsic muscles help in maintaining concavity of the foot and help in stabilizing the tarsal and metatarsal bones.[6,7] The IFM may have a functional role for stabilizing the foot during single-limb balance.[9] They are also active during gait and function similar to elastic springs by supporting the MLA and maintaining the concavity of the foot.[10] It is therefore suggested that effective neuromuscular control of the IFM is essential in order to stabilize the tarsal and metatarsal bones and modulate the rate of pronation.[10] This 'fine tune' control is not only required for static control of the MLA, but is likely essential for the dynamic control of the MLA from the heel-strike to the toe-off phase of the gait cycle.[6,9,10]

The effectiveness in Group A could be due to added effect of orthosis. Jung D.Y et.al stated foot orthosis comined with short foot exercise is more effective in increasing strength of intrinsic foot muscles compared to orthosis alone[22].

In Group B, there is no significant improvement in Navicular drop correction where has there is significant improvement in disability questionnaire. This could be due the effect of conventional exercises and foot orthosis used same as in Group A.

The orthotics used in the both group might have helped in correction of Navicular drop. Kogler GF et.al concluded the patterns of plantar aponeurosis strain observed in cadaveric tests suggest that certain types of orthoses are more effective in correction of foot arches.[23] Lmhauser C W et. all concluded that semi-rigid foot and ankle orthoses acted to stabilize the medical longitudinal arch. It was concluded that treatment of flat foot deformity should include use of in shoe orthoses to partially restore arch and stabilize hind fact three conditions were tested- intact unbraced, flatfoot unbraced and flatfoot braced. Flatfoot deformity was created by sectioning the main support structures of medical longitudinal arch six different braced were tested including two in shoe orthoses three ankle braced and one moulded ankle foot orthoses.[24] Shing-Iye Chen et. all concluded a greater calcaneal eversion might occur when foot arch is impeded during mid-stance of walking. As orthoses are often prescribed to correct excessive rearfoot motion, constraint on modfoot navicular drop needs to be considered.[25]

Therefore, based on the findings the present study found that there is a statistically significant difference between the effect of intrinsic foot muscle strengthening with orthosis and conventional physiotherapy with orthosis in preventing reduce navicular drop and improving

pain disability. Hence, the present rejects the null hypothesis.

LIMITATIONS OF THE STUDY

No blinding was done in the study. Only workers with Navicular drop were included in the study. Workers having other conditions (back pain, neck pain etc.) were not included in the study. Range of motion was not checked. Only male workers were taken.

RECCOMENDATION FOR FUTURE RESEARCH

The study could be done on both male and female. Range of motion can be checked. Other conditions with navicular drop could also be checked. Other specific outcome measures like foot function index, VAS can be used.

Conclusion

It is concluded that 8 weeks of intrinsic muscle strengthening exercise with orthosis is more effective than conventional physiotherapy exercises with orthosis in reducing navicular drop and improving Pain Disability in prolong standing workers.

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Conflicts of interest: None

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