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Role of footwear alteration along with conventional physiotherapy in Osteoarthritis knee

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Abstract

Inspite of vast array of conservative treatment interventions for medial knee osteoarthritis, their effectiveness in its management is still contentious. Numerous researchers have suggested the role of footwear modification in reducing medial knee joint space load and hence reducing pain and improving functional status. However, most of the studies were cross-sectional in nature and have not seen the alteration in compendium of factors like radiographic changes, static alignment, kinesiological factors, gait parameters and most importantly plantar pressure distribution following 6 months of footwear modification along with conservative physiotherapy. The results of the present study suggested that footwear alteration along with conventional physiotherapy was effective not only in improving clinical outcomes but also increasing medial knee joint space width, changing static alignment, improving kinesiological factors, gait parameters and plantar pressure distribution in patients of osteoarthritis knee.

Key Words: Footwear alteration; Knee; Osteoarthritis; Joint Space Width; Static alignment; Kinesiology; Gait; Plantar pressure; Pain; Functional status

Introduction

Osteoarthritis of the knee is a common painful chronic disease whose prevalence is increasing and for which there are few efficacious treatment options *(Felson et al, 2000)*. The increase in rates of knee replacement for osteoarthritis has made the identification of effective nonsurgical treatments a high priority. Medial osteoarthritis is one of the most common subtypes of knee osteoarthritis *(Parkes et al, 2013)*. It was directly linked with a varus deformity causing a change in the axial alignment on the knee and with the static load bearing axis transmitting through the medial side rather than the center of the knee. This change in alignment and load bearing axis of the knee will increase the loading transmitted through the medial compartment and accelerate the degeneration of the cartilage, which is believed to be one of the main causes of medial knee OA *(Mehta and Mulgaonkar, 2004)*. In the light of these cross-sectional studies, the present study was carried out in a longitudinal design with an aim to not only provide symptomatic relief to OA knee patients but also address the biomechanical alterations.

Lateral wedge insoles are used for conservative treatment of OA when there is medial compartment narrowing. Although knee OA is not a foot condition, foot orthosis can alter the ground reaction

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forces affecting the more proximal joints, such as knee and therefore could be effective in treatment of knee OA *(Hennessey, 2007)*. The wedge is placed under the sole of the foot and angulated so that it is thicker over lateral than medial edge transferring loading during weight bearing from medial to the lateral knee compartment. Studies have documented a modest 5% to 6% reduction in the external knee adduction moment, a measure of medial vs lateral loading *(Keating et al, 1993; Kakihana et al, 2005; Butler et al, 2007; Hinman et al, 2008)*. In a study conducted by *Hinman and colleagues (2009)*, twenty people with medial compartment OA underwent gait analysis in their own shoes wearing i) no insoles and; ii) insoles wedged laterally 5 degrees, in random order. They concluded that effects of laterally wedged insoles on the adduction moment do not appear to decline after one month of continuous use, suggesting that significant wedge degradation does not occur over the short term. In an another study *(Barrios et al, 2013),* 3- dimensional gait data were captured in an intervention group of 19 patients with symptomatic medial knee osteoarthritis wearing their prescribed laterally wedged foot orthoses at 0 and 12 months. Wedge amounts were prescribed based on symptom response to a step down test. It was observed that mechanical effectiveness of lateral wedging did not decrease over 12 months' time period. Thus both short term and long term biomechanical effectiveness of lateral wedge has been reported in the management of medial osteoarthritis knee.

Materials & Methods

This was an experimental, interventional study that was conducted at the Research Lab, Department of Physiotherapy, Punjabi University, Patiala. The data was also collected from Knee Clinic, Rotary Club (Mid Town), SST Nagar, Patiala, Physiotherapy OPD, Geriatric Centre, Patiala and Out Patient Department (OPD), Bhai Khanaiya Health Centre, Punjabi University, Patiala. Approval to conduct the research study was obtained from Institutional Ethical Committee, Punjabi University, Patiala. Thirty patients (mean age 58.33 ± 6.31 years; mean BMI 27.89 ± 3.89; 05 Males & 25 Females) with medial compartment OA (Grade – II & - III) were included in the study. 13 patients had right side involvement of medial knee OA and 17 patients had left sided involvement. The exclusion criteria were history of fracture in the area of knee joint under study or secondary OA knee; severe osteoporosis; any major lower limb surgery in the past; locomotion with assistive device; lower extremity injuries (not older than one year); Neurological disorders such as polyneuropathy, hemiplegia, parkinson disease, stroke; Grade- 4 Osteoarthritis (Osteoarthritis grading system - *Kellgren and Lawrence, (1957*); Orthostatic Hypotension and patients suffering from acute illness, systemic /infectious diseases or disorders. Informed consent was obtained from each subject before starting the assessment.

As per the study protocol, the intervention group (n=30) received conventional physiotherapy that consisted of administration of hot packs and interferential therapy followed by exercise regime along with footwear modification. Footwear modifications included application of 5 degrees of lateral wedge in their shoes and were instructed to wear

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them while doing activities of daily living. The total duration of intervention was 6 months. The evaluation of osteoarthritis knee was carried out at pre-intervention and post-intervention stages (3 months & 6 months). Clinical outcome (VAS & WOMAC), radiographic joint space narrowing (using radiographs in standing), static alignment (Q angle, Genu varum & Tibial Torsion), kinesiological factors (Quadriceps & Hamstrings strength, Quadriceps lag, Hamstrings flexibility and Knee range of motion), gait parameters (Step length, Stride length, Toe out, Cadence & Gait velocity) and plantar pressure distribution were assessed.

The role of footwear modification along with conventional physiotherapy was evaluated by comparison of outcomes at pre-intervention, in between the intervention (i.e. 3 months) and at the completion of intervention (i.e. 6 months) stages. Analysis of Variance (ANOVA) was used for this purpose followed by multiple comparisons of mean differences using Scheffe's post hoc test. The SPSS - 17.0 program was applied for analyses of data and a *p* value of 0.05 was considered as significant level.

Results and Discussion:

Table: 1 Comparison of clinical outcomes (Pain and Functional status) in osteoarthritis knee at different levels of intervention.

Clinical Outcome	Levels of Intervention			F-Value	Mean difference (Scheffe's Post Hoc)		
	Pre intervention Mean± SD	3 Months Post intervention Mean± SD	6 Months Post intervention Mean± SD		Preintervention vs 3 Months Post intervention	Preintervention vs 6 Months Post intervention	3 Months Post intervention vs 6 Months Post intervention
Intensity of Knee Pain (VAS score)	7.47 ± 1.01	3.2 ± 1.24	3.13 ± 0.82	290.45*	4.27*	6.33*	2.07*
Functional Status (WOMAC)	80.63±10.90	37.13±14.23	14.45±10.01	241.40*	43.50*	66.18*	22.68*

Note *p < 0.05

Table 2: Comparison of knee joint space width in osteoarthritis knee at different levels of intervention.

Radiographic changes	Levels of Intervention			F-Value	Mean difference (Scheffe's post hoc)		
	Pre intervention Mean± SD	3 Months Post intervention Mean± SD	6 Months Post intervention Mean± SD		Pre intervention vs 3 Months Post intervention	Pre intervention vs 6 Months Post intervention	3 Months Post intervention vs 6 Months Post intervention
Joint Space Width (mm)	2.29 ± 1.43	2.96 ± 1.49	3.75 ± 1.36	7.87*	-0.67	-1.47*	-0.79

Note *p < 0.05

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It is observed from Table 2 that average knee joint space width increased from 2.29±1.43 to 2.96±1.49 following 3 months of Footwear alteration along with conventional physiotherapy. It was observed further to increase to 3.75±1.36 on the completion of six months of intervention. This increase in knee joint space width was statistically significant (F = 7.87, table 3). The mean difference between preintervention and 6 months postintervention was statistically significant whereas difference between other levels of interventions was found to be statistically nonsignificant. Thus the osteoarthritic patients who receive footwear alteration along with conventional physiotherapy have statistically significant improvement in the knee joint space width after the administration of six months of intervention.

Table: 3 Comparison of static alignment in osteoarthritis knee at different levels of intervention

Static alignment	Levels of Intervention			F-Value	Mean difference (Scheffe's post hoc)		
	Pre-intervention Mean± SD	3-Months Post-intervention Mean± SD	6-Months Post-intervention Mean± SD		Pre-intervention vs 3 Months Post-intervention	Pre-intervention vs 6 Months Post-intervention	3-Months Post-intervention vs 6 Months Post-intervention
Q-Angle	10.67 ± 2.01	12.57 ± 1.74	14.13 ± 1.48	29.40*	-1.90*	-3.47*	-1.57*
Genu Varum	- 4.82 ± 2.77	- 2.33 ± 2.28	- 1.37 ± 2.11	16.46*	2.48*	3.45*	0.97
Tibial Torsion	19.43 ± 4.55	17.05 ± 4.90	15.85 ± 4.96	4.32*	2.38	3.58	1.20

Note *p < 0.05

Table: 4. Comparison of kinesiological factors in osteoarthritis knee at different levels of intervention

Kinesiological factors	Levels of Intervention			F-Value	Mean difference (Scheffe's post hoc)		
	Pre-intervention Mean± SD	3-Months Post-intervention Mean± SD	6-Months Post-intervention Mean± SD		Pre-intervention vs 3 Months Post-intervention	Pre-intervention vs 6 Months Post-intervention	3-Months Post-intervention vs 6-Months Post-intervention
Quadriceps Strength (Kgs)	16.19 ± 3.13	18.02 ± 3.17	19.47 ± 3.35	7.84*	-1.83	-3.28*	-1.45
Hamstring Strength (Kgs)	11.97 ± 2.04	13.82 ± 2.16	15.04 ± 1.01	15.23*	-1.84*	-3.06*	-1.22
Hamstring Flexibility (cms)	13.43 ± 2.91	12.20 ± 2.37	11.93 ± 2.56	2.79	-	-	-
Quadriceps Lag (degrees)	2.70 ± 2.94	1.20 ± 1.79	0.67 ± 1.58	6.98*	1.50*	2.03*	0.53
Knee Range Of Motion (degrees)	109.93 ± 5.60	113.93 ± 4.46	116.40 ± 3.95	14.32*	-4.00*	-6.47*	-2.47

Note *p < 0.05

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Table 3, presents the mean of Q-angle (degree), Genu varum (degree) and Tibial torsion (degree) within in the group at preintervention, 3 months postintervention and 6 months postinterventions. The calculated F values for all the biomechanical factors [Q angle (29.40), Genu varum (16.46) and Tibial torsion (4.32)] were found to be statistically significant. The multiple comparisons of mean difference of static alignment by using Scheffe's post hoc showed that for Q angle mean difference is statistically significant at all levels of interventions whereas for tibial torsion, it was significant only between preintervention and 6 months postintervention stages. Additionally for genu varum mean difference is statistically significant between pre intervention and 3 months postintervention as well as preintervention and 6 months post intervention stages.

The calculated F value for Quadriceps strength (7.84), Hamstring strength (15.23), Quadriceps lag (6.98) and Knee range of motion (14.32) was found to be statistically highly significant where as the F value for Hamstring Flexibility (2.79) was found to be statistically non significant as shown in Table 4. The mean difference between pre-intervention and 6 months post-intervention was found to be statistically significant for all the kinesiological parameters. However the mean difference between pre and 3 months post-intervention as well as 6 months post-intervention stages was statistically significant only for hamstring strength, quadriceps lag and knee range of motion.

Table: 5 Comparison of gait parameters in osteoarthritis knee at different levels of intervention

Gait parameters	Levels of Intervention			F-Value	Mean difference (Scheffe's post hoc)		
	Pre-intervention Mean± SD	3-Months Post-intervention Mean± SD	6-Months Post-intervention Mean± SD		Pre-intervention vs 3 Months Post-intervention	Pre-intervention vs 6 Months Post-intervention	3-Months Post-intervention vs 6 Months Post-intervention
Step Length (cm)	43.63 ± 6.08	46.63 ± 5.22	48.88 ± 4.84	7.12	-3.00	-5.25*	-2.25
Stride Length (cm)	87.33 ±12.22	93.08 ± 10.60	97.70 ± 9.75	6.81	-5.75	-10.37*	-4.62
Toe-Out (degrees)	12.26 ± 1.79	10.63 ± 1.30	9.63 ± 0.81	28.50	1.63*	2.63*	1.00*
Cadence	91.43 ± 8.05	99.70 ± 8.98	106.40 ± 7.73	24.64	-8.27*	-14.97*	6.70*
Velocity (cm/sec)	75.27 ± 5.50	81.59 ± 5.38	85.95 ± 5.75	28.09	-6.32*	-10.67*	-4.35*

Note *p < 0.05

Table 5 presents the average step length, stride length, toe out, cadence and gait velocity at different levels of interventions in the Experimental group – I. The calculated F value for all of these parameters [step length (7.12), stride length (6.81), toe out (28.50), cadence (24.64) and gait velocity (28.09)] was found to be significant at $p<0.05$. the multiple comparisons carried out by using Scheffe's post hoc indicated that the mean difference of gait parameters namely toe

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out cadence and velocity was statistically significant at all the levels of interventions. On the other hand this difference was significant only between pre and 6 months post-intervention for step length and stride length.

Table 6: Comparison of plantar pressure distribution mask in Osteoarthritis knee at different levels of intervention

Plantar Pressure Distribution	Levels of Intervention			F-Value	Mean difference (Scheffe's post hoc)		
	Pre-intervention Mean± SD	3-Months Post-intervention Mean± SD	6-Months Post-intervention Mean± SD		Pre-intervention vs 3 Months Post-intervention	Pre-intervention vs 6 Months Post-intervention	3-Months Post-intervention vs 6 Months Post-intervention
Anterior Mask (UM+UL+MM)	41.64 ± 8.26	45.63 ± 7.78	46.41 ± 8.22	3.01	-	-	-
Posterior Mask (ML + LM + LL)	58.92 ± 7.94	53.78 ± 8.12	53.35 ± 7.97	4.48*	5.13	5.57*	0.44
Medial Mask (UM + MM + LM)	46.73 ± 5.04	55.31 ± 6.04	58.81 ± 6.53	33.25*	-8.58*	-12.08*	-3.49
Lateral Mask (UL + ML + LL)	53.83 ± 5.18	44.11 ± 5.75	40.95 ± 6.22	41.15*	9.72*	12.87*	3.16

Note *p < 0.05

The mean values of anterior mask, posterior mask, medial mask and lateral masks of plantar pressure distribution at different levels of interventions have been illustrated in Table 6. The results of one way ANOVA suggested that the changes in plantar pressure distribution were statistically significant for posterior mask (4.48), medial mask (33.25) and lateral mask (41.15) but not for the anterior mask (3.01). The mean difference of plantar pressure distribution was found to be statistically significant from base value to 3 months post intervention as well as base value to 6 months post-intervention for both medial mask and lateral mask while it was significant only after 6 months of intervention for posterior mask.

Discussion and Conclusions

Knee Osteoarthritis is a musculoskeletal condition prevalent in adults that causes considerable pain, immobility and disability and imposes a significant economic burden on those afflicted by it *(Raja and Dewan, 2011*). Keeping this in mind, the present study was designed to decrease the biomechanical load on medial compartment of knee and thereby reduce clinical symptoms and the risk of further development of medial OA knee.

The mean varus alignment was significantly reduced by 3.4 degrees in the patients receiving footwear modification along with conservative physiotherapy. These findings are contrary to the observations of *Van Raaij et al (2010)* who demonstrated that neither the lateral wedge nor the valgus brace achieved the correction of knee varus malalignment in the frontal plane. In their study, the authors showed that the mean varus alignment for the insole group (6.9

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degrees; SD, 3.6 degrees) was similar ($p = 0.8$) at baseline compared with when wearing the wedge (6.9 degrees; SD, 4.1 degrees). Conversely, the present findings are well in line with the results of the study conducted by *Zhang et al (2012)* who suggested that valgus knee bracing showed a significant smaller knee varus degree with a 2.90° reduction compared with control condition, meanwhile a 2.81° reduction compared with lateral wedge condition ($p < 0.05$).

It has been observed that after 6 months of intervention, hamstring and quadriceps strength has shown significant improvement. These findings can be attributed to biomechanical effectiveness that was achieved by the application of lateral wedge, as it has been reported that the muscles at the medial compartment of knee (vastus medialis, medial gastrocnemius and medial hamstrings) present with a pathological protective patterns which increase the compressive forces and moments acting on the affected compartment *(Lawek et al, 2005)*. Thus only muscle strengthening without biomechanical correction in the control group was not sufficient to improve the quadriceps strength ($p = 0.09$) and hence quadriceps lag ($p = 0.53$). On the other hand quadriceps lag was significantly improved. Knee range of motion was another kinesiological parameter studied in the present investigation which has significantly improved. Several studies have demonstrated the effect of hot pack, interferential therapy and exercise therapy in reducing pain and stiffness and hence improving joint range of motion.

All the gait parameters namely Step length, stride length, toe out, cadence and velocity were improved significantly. These results differ from the previous studies that have been unable to show improvements in gait parameters either with exercise program *(Thorstensson et al, 2007),* or lateral wedge *(Hinman et al, 2009; Zhang et al, 2012)*. The difference between these previous studies and present study is that: i) there was average reduction in knee adduction moment in the study conducted by *Thorstensson et al (2007)* and ii) studies conducted by *Hinman et al (2009*) and *Zhang et al (2012)* were very short term studies. Six months administration of intervention resulted into a statistically significant improvement in pain. Similar findings have been reported by *Sattari and Ashraf (2011)* and this could be attributed to the unloading of medial compartment *(Miyazaki et al, 2002; Zhang et al, 2012),* decrease in the knee adduction moment *(Baliunas et al, 2002; Zhang et al, 2012)* and an increase in the medial joint space *(Richard et al, 2005; Raja and Dewan, 2011)*. This reduction in pain and improvement in walking ability is believed to be naturally translated into enhanced functional scores (WOMAC) of the participants ($p = 0.00$). Additionally pain and functional outcome has improved even after 3 months of intervention. These results are consistent with the many of the previous studies reported.

Hinman et al (2008) conducted a study on 40 people with medial compartment OA and demonstrated that laterally wedge insoles resulted in an immediate reduction in walking pain and knee adduction moment. The improvement in pain and physical function were reported by the cohort after 3 months of treatment with insoles. This study provides an objective measurement of function by analysis of gait symmetry.

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This was measured in 30 patients on four separate occasions: immediately before and after initial fitting and then again at three months with the brace on and off. All patients reported immediate symptomatic improvement with less pain on walking. Hence, footwear alteration along with conventional physiotherapy is found to be effective in improving clinical outcomes, radiographic joint space width, static alignment, kinesiological factors, gait parameters and plantar pressure distribution in patients of osteoarthritis knee. Thus, the results of the present study may help clinicians to find a novel way of use of lateral wedge along with conventional physiotherapy, to help patients with early medial OA knee in future.

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