Original Article

INFLUENCE OF CONVENTIONAL POST TOTAL KNEE REPLACEMENT REHABILITATION PROTOCOL ON ANGLES OF FLAT FOOT

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ABSTRACT

Background and introduction: Purpose is to find the influence of conventional post total knee replacement rehabilitation protocol on angles of flat foot such as degree of navicular drop and relaxed calcaneal stance phase angles following unilateral Total Knee Replacement.

Method: Pre to post test single group experimental study design. 60 subjects undergoing unilateral total knee replacement recruited and were treated with 4 weeks of conventional post total knee replacement rehabilitation protocol following surgery. Before surgery and after 4 weeks of post surgery outcomes measurements such as there navicular drop test angles and relaxed calcaneal stance phase angles were measured.

Results: Analysis using Paired 't' test and Wilcoxon signed rank test found that in operated limb there is a statistically significant ($p<0.05$) change in means of Navicular Drop Test angle and Relaxed Calcaneal Stance Phase angle during Weight bearing and Non-weight bearing after 4 weeks of post TKR.

Conclusion: It was concluded that there is significant influence of 4 weeks of conventional post TKR Rehabilitation protocol on improving angles of flat foot that there was retaining of foot arch towards normal angle by increase in navicular angles and decrease in relaxed calcaneal stance phase angle in subjects with unilateral TKR.

KEYWORDS: TKR; Navicular Angles; Calcaneal Stance Phase; Rehabilitation; Flat Foot; Foot Angles.

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Access this Article online

Quick Response code

International Journal of Physiotherapy and Research
ISSN 2321- 1822
www.ijmhr.org/ijpr.html

Received: 16-11-2013 Accepted: 28-11-2013
Peer Review: 16-11-2013 Published: 11-12-2013

INTRODUCTION

Flatfoot is a deformity characterized with decrease in medial longitudinal arch of the foot.[1] Knee osteoarthritis (OA) is a common painful degenerative condition of knee that affects large population causing loss of function.[2] People with medial compartment knee osteoarthritis have largely been reported to have flatfoot.[3] In medial compartment OA knees change in gait biomechanics in particular the knee adduction moment leads to increase loading on medial compartment of knee and further transmitting the weight to the medial arch of foot causes a fall in the arch of the foot called acquired flat foot.[4,5,6]

According to the American study, 19% of the osteoarthritis population were with flat feet.[7]

Total knee replacement (TKR) is a procedure done to cut away the damaged bone of the knee joint and replace it with prosthesis to prevent the bones from rubbing together and provides a smooth knee joint.[8,9] It was found that 95% of his total knee replacement patient are with flat feet.[10,11] Sancheti K H stated that genu varum deformities in osteoarthrosis are associated with heel valgus deformity and they hypothesize that this deformity persists even after correction of the knee deformity after TKR[12], remains unanswered after total knee replacement.[13] This deformity lead to malalignment of the new

operative knee joint causing instability, repeated ankle pains, loosening of the implant, early revision surgery and altogether a dissatisfaction by the subject.[14,15] It is been seen that even after a year of the TKR , the complaints and dissatisfaction regarding the dull aching pain around the medial knee joint line, tibial shin and ankle continues to be the complains in post total knee replacement.[16] This pain might be the result of altered foot complex. If this pain is not handled on time the subjects may become depressed and restrict their activity levels.[17]

In conventional total knee replacement (TKR) protocol where in early rehabilitation is practiced, considering foot and ankle complex remains unanswered.[18,19]It remains inconclusive on effect of conventional post TKR rehabilitation protocol on flat foot correction.

This study is with research question whether the conventional post TKR protocol does have an effect on correction of angles of flat foot in subjects with post TKR. It will be beneficial to know the influence of conventional total knee replacement protocol on flat foot angle and thereby to decide the interventions on flatfoot correction along with conventional total knee replacement protocol to prevent long term complication in post TKR subjects. Hence, the purpose is to find the influences of conventional total knee replacement rehabilitation protocol on flat foot angles such as navicular drop angle and relaxed calcaneal stance phase angle in subjects with osteoarthritis of knee undergoing total knee replacement. It was hypothesized that there will be significant change in the angle of navicular drop and relaxed calcaneal stance phase in flat foot following conventional post total knee replacement rehabilitation protocol. The objective of this study to measure and determine the navicular drop, relaxed calcaneal stance position (RCSP) angles changes before and after conventional TKR rehabilitation protocol.

MATERIALS AND METHODS

Pre and post test single group experimental design**.** As this study involved human subjects the Ethical Clearance has been obtained from the Human Ethical Committee of KTG College of Physiotherapy and K.T.G Hospital, Bangalore as per the ethical guidelines for Bio-medical research on human subjects. Convenience sampling recruited 60 subjects with history of osteoarthritis knee undergoing planed TKR from various hospitals across Bangalore. Subjects were included with age of 60 to 70 years, both male and female undergoing Unilateral Total Knee Replacement with the history of Knee Osteoarthritis, Body Mass Index above 25 and below 30, presence of 2nd degree flat foot categorized based on Feiss line and Foot Posture Index (FPI),[24] who were able to bear weight on both the lower limbs and stand without assistance before Total Knee Replacement surgery, who had a minimum score of 25 on the Mini-mental status examination, who gave written consent to participate in the study. Subjects excluded with multi joint disorders like Rheumatiod Arthritis, Gout etc, undergoing bilateral Total Knee Replacement, neurological impairment in lower limb causing flat foot, congenital and familial history of flat foot, who were severely disabled to bear weight on both the lower limbs with or without assistance before Total Knee Replacement. Materials Used were Ruler, Goniometer, Water soluble Marker pen, Pen , Paper, Plinth, Stepper.

Procedure:

Individually informed consent was taken from all the 60 subjects selected for the study on the basis of inclusion criteria. Subject was evaluated for outcome measurements such as Navicular Drop angle, Relaxed Calcaneal Stance Phase angle in degrees in operated and non-operated limb before a day of surgery and re**-**evaluated after receiving 4 weeks of total knee replacement protocol.

Conventional post TKR rehabilitation protocol[13s]

The frequency, duration and intensity of exercise were decided based on the patients performance and the improvements were targeted to achieve with respect to the days of the protocol.

Post operative day 0: Physiotherapy was started immediately with 2 hours of the surgery. Continuous passive motion (CPM) upto 30 degrees, Breathing exercises, Ankle pumps: subject was asked to move the ankle up and

down, Static quadriceps exercises, Static hamstring exercises.

Post operative day 1: Deep breathing exercises, Ankle pumps: subject was asked to move the ankle up and down, Heel slides: while lying supine subject was asked to slowly slide the heel towards the buttocks and then straighten the leg. Static Quadriceps exercises: subject was asked to tighten the knee and hold for a count of 5 and relax. Static hamstring exercises: subject was asked to press his heel on the towel hold for a count of 5 and relax. Straight leg raising: subjects was asked raises the leg straight up in the air without bending the knee in supine. Quadriceps drills: subject was asked to raise the leg up straight up with subject in sitting at the edge of the bed. Subject was made to sit up in bed and also made to walk a few steps with a walker.

Post-operative day 3: Subject gradually started to do the exercises with minimum assistance. And was independently moving around with a walker for a small distance.

Post-operative day 5: Range of motion at the knee was 90 degrees. Subject was walking independently with walker. Subject was trained to climb up and down the stairs.

2-4 Weeks: Subject was encouraged to walk with cane. Strengthening exercises were started for hip and knee muscles using free weights.

By the end of 4week: Subject was walking without support. Subject was independent in his activity of ADLS.[25,26]

Outcome measures:

Out come measurements such as Navicular Drop angle, Relaxed Calcaneal Stance Phase angle were measured in degrees in operated and non-operated limb.

1. Navicular drop test[13]

In Navicular drop test the subject was in upright position toes pointing straight forward with unaffected leg in forward position over the affected leg. The weight bearing knee is placed vertically above the other leg. The therapist marked the medial side of the head of the first metatarsal bone, navicular tuberosity and a point on the Achilles tendon. The position of the navicular bone was measured with the centre of the goniometer. Navicular tuberosity and arm of the goniometer on the head of the first metatarsal and the marking on the Achilles tendon. The angle between two visualized straight lines; one between the head and the first metatarsal bone and navicular tuberosity and between the marking between the Achilles tendon and the navicular tuberosity. The increment of the measurement of the goniometer used in the study was 2.5 degrees.[13]

2. Relaxed calcaneal stance phase[13]

Relaxed calcaneal stance phase subject was made to lie prone. Examiner then marked a point over the midline of the calcaneus on the insertion of Achilles tendon. Next the examiner marked two points on lower third of the leg in the midline. The examiner places the subtalar joint in neutral position and joined the points to draw a line. The patient was then made to stand at the edge of the stepper with heel facing the examiner. With the goniometer the examiner measured the angle formed by the bisection of the posterior aspect of the calcaneus to the stepper (supporting surface) during relaxed standing.

Figure 1: Technique of measurement of NDT angles in weight-bearing.

Figure 2: Relaxed Calcaneal Stance Phase angle measurement in non-weight bearing.

Statistical Methods:

Descriptive statistical analysis has been carried out in the present study and presented as mean ± SD. Significance is assessed at 5 % level of significance with p value 0.05 less than this is considered as statistically significant difference. Pearson Chi-Square test and has been used to

analyze the significant of basic characteristic of gender, age and side distribution of the subjects studied. Paired 't' test as a parametric and Wilcoxon signed rank test as a non-parametric test have been used to analysis the variables before surgery to after 4 weeks of surgery with calculation of percentage of change. Pearson coefficient of correlation as a parametric test and Spearman's rho rank test as a non parametric test has been used to correlate the association between operated and non-operated limb measurements.

The Statistical software namely SPSS 16.0 , 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 AND TABLES

Basic			Percentage
Number of subjects studied (n)		60	
Age in years (Mean± SD)		65.55± 3.10 (60-70)	
Gender	Males	28	46.70%
	Females	32	53.30%
Side	Right	33	55.00%
	Left	27	45.00%

a- Pearson Chi-Square

Table 1: Basic Characteristics of the subjects studied.

The study was carried on 60 subjects with mean age 65.55 years and there were 28 males 32 females were included in the study (Table: 1).

		Before surgery (Mean±SD) min-max	4 week post TKR (Mean±SD) min-max	Perecntage change	Z value (Non parametric significance)	t value [a] (Parametric)	Parametric Significance P value	95%Confidence interval of the difference Lower	Upper	Effect Size (r)
		Operated limb								
Navicular Drop Test in degrees	Weight bearing	24.60± 10.56 (10- 48)	29.00±11.17 (9-55)	17.88%	-2.365 P =0.018**	-2.571	P =0.013**	-7.82	-0.97	0.19 (Medium)
	Non-weight	29.05± 8.76 (14- 45)	22.53±6.51 (10-40)	-22.44%	-4.361 P <0.000**	5.246	P <0.000**	4.03	9	0.38 (Large)
Relaxed Calcaneal Stance Phase in degrees	Weight bearing	35.82± 11.10 (12- 50)	33.02± 11.71 (10-50)	-7.81%	-3.232** P =0.001**	3.12	P =0.003**	1	4.59	0.12 (Medium)
	Non-weight	32.52± 10.49 (5- 50)	24.70±8.87 (5-48)	-24.04%	-5.429 P <0.000**	6.955	P <0.000**	5.56	10.06	0.37 (Large)
		Non-operated limb								
Navicular Drop Test in degrees	Weight bearing	22.18± 7.69 (5- 40)	33.95±8.72 (15-48)	53.06%	-5.496 P <0.000**	-7.752	P <0.000**	-14.8	-8.72	0.58 (Large)
	Non-weight	27.60± 8.86 (11- 48)	29.27±7.49 (10-40)	6.05%	-1.371 P =0 .170	-1.228	P=0.224 (NS)	-4.38	1.05	0.1 (Small)
Relaxed Calcaneal Stance Phase in degrees	Weight bearing	33.72± 10.17 (10- 50)	33.35± 10.43 (12-48)	-1.09%	-0.462 P =0 .644	0.447	P =0 .657(NS)	-1.27	2	0.01 (Small)
	Non-weight bearing	30.83± 9.95 (10- 47)	22.88±7.77 (10-45)	-25.78%	-4.935 P <0.000**	6.158	P <0.000**	5.36	10.53	0.38 (Large)

Table 2: Analysis of Navicular Drop angle, Relaxed Calcaneal Stance Phase angle in operated and non-operated limb.

		Spearman's rho Correlation Coefficient r value	Pearson Correlation Coefficient r value	Parametric Significance P value	Level of parametric correlation
		Before Surgery			
Navicular Drop Test	Weight bearing	0.379 P=0 .001	**0.378**	p=0.001**	Moderate positive correlation
	Non-weight bearing	0.116 P=0.189	**0.132**	P= 0.157 (NS)	Weak positive correlation
Relaxed Calcaneal Stance Phase	Weight bearing	0.738 P=0.000	**0.789**	P= 0.000**	Strong positive correlation
	Non-weight bearing	0.659 P=0.000	**0.428**	P=0.000**	Moderate positive correlation
		After Surgery			
Navicular Drop Test	Weight bearing	0.406 P=0.001	**0.462**	P=0.000**	Moderate positive correlation
	Non-weight bearing	0.280 P=0.015	**0.226**	P=0.041*	Weak positive correlation
Relaxed Calcaneal Stance Phase	Weight bearing	0.787 P=0.000	**0.801**	P=0.000**	Strong positive correlation
	Non-weight bearing	0.413 P=0.001	**0.356**	P=0.003**	Moderate positive correlation

Table 3: Correlation of means between operated and non-operated limb.

Analysis using Paired 't' test and Wilcoxon signed rank test (Table: 2) found that in operated limb there is a statistically significant change in means of Navicular Drop Test angle and Relaxed Calcaneal Stance Phase angle during Weight bearing and Non-weight bearing.

In non-operated limb there is a statistically significant change in Navicular Drop Test angle in Weight bearing and Relaxed Calcaneal Stance Phase angle in Non-weight bearing where as there is no statistically significant change in means of Navicular Drop Test angle in Non-weight bearing and Relaxed Calcaneal Stance Phase angle in Weight bearing limb. (Table: 3)

Analysis using Pearson coefficient of correlation and Spearman's rho rank test to correlate the association between operated and non-operated limb measurements it was found that before surgery and after 4 weeks of post TKR there is significant moderate to strong correlation in means of Navicular Drop Test and Relaxed Calcaneal Stance Phase when correlated between operated and non-operated limb shows that the means in both the limbs were related. However there is weak positive correlation in Navicular Drop Test during Non-weight bearing before and after 4 weeks of post surgery.

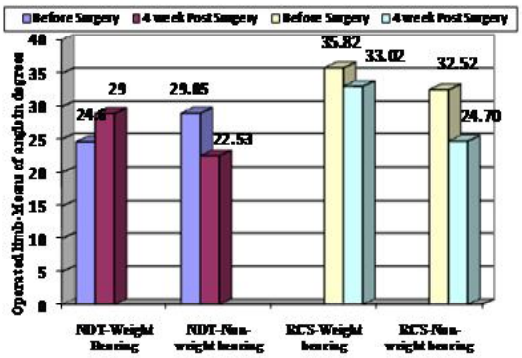

Chart- 1: Analysis of Navicular Drop Test angle and Relaxed Calcaneal Stance Phase angle in operated limb (Pre to post test analysis).

The above graph shows that there is a statistically significant reduction in means of Navicular Drop Test angle and Relaxed Calcaneal Stance Phase angle during Weight bearing and Non-weight bearing in operated limb.

Graph in Chart 2 shows that in non-operated limb there is a statistically significant change in Navicular Drop Test angle in Weight bearing and Relaxed Calcaneal Stance Phase angle in Non-weight bearing where as there is no statistically significant change in means of Navicular Drop Test angle in Non-weight bearing and Relaxed Calcaneal Stance Phase angle in Weight bearing limb.

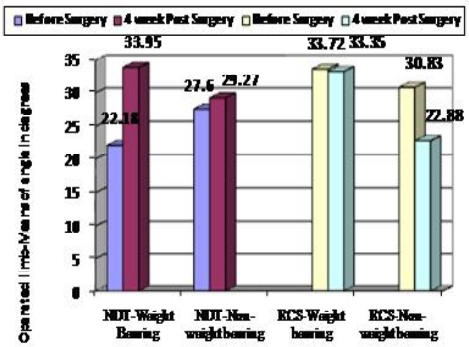

Chart- 2: Analysis of Navicular Drop Test angle and Relaxed Calcaneal Stance Phase angle in non-operated limb (Pre to post test analysis).

DISCUSSION

Findings from the study shows that there is significant influence of 4 weeks post TKR Rehabilitation protocol on improving angles of flat foot that shows, there is retention of foot arch towards normal angle by increase in NDT angles and decrease in RCSP angle following 4 week protocol.

The NDT angle is angle formed by 1st metatarsal to navicular bone and calcaneal tubercle to navicular bone. In a normal foot the NDT angle is 30^0 which increases in pes cavus foot and decreases in pes planus foot.

In operated limb there is retaining angles towards normal showing statistically significant increase in NDT angle and decrease in RCSP angle during weight bearing following 4 weeks protocol. This could be due to the foot arches that are dependent on navicular bone, calcaneal bone, and 1st metatarsal bone connected together by the bow string mechanism of plantar fascia. Decrease in adduction force on the medial compartment of knee following TKR changes line of gravity and decrease base of support influencing correction of flat foot.[24] Rasmus G Nielsen[25] found that per 10 mm increase in foot length, NDT increases by 0.40mm for males and 0.31mm for females and concluded that NDT is dependent on foot length and gender but not on age or BMI. Strengthening exercises and gait training for correction of lurch (antalgic gait) changed NDT angles.[14,15] The neuromuscular control would cause change in the NDT angle and RCSP angle in weight bearing.[27]

Yi-Ching Huang [28]found balance training on TKR had beneficial effect on the functional recovery and mobility outcome.

In non-operated limb the NDT angles during weight bearing increased with decreased load on the non-operated limb. Pain, edema of the operated limb also change NDT angles, however post TKR mobility increases, pain decreases along due strengthening of the non-operated limb as per the protocol. NDT angle during non-weight bearing remained unchanged as NDT angles are dependent on weight bearing and the study included flexible flatfoot secondary to OA. In non-operated limb RCSP angle during non weight bearing is increased because the calcaneum is everted due to shortened Achilles tendon along with degenerated changes in the non operated limb. H Kawahara etal[27] found that adduction moment of the knee causes dynamic loading on the medial compartment and cause OA to contralateral side.

On comparing the NDT angle and RCSP angle pre TKR and 4 weeks post TKR showed that there is significant reduction in means of NDT angle and RCSP angle during Weight bearing and Non-weight bearing in operated limb, thus proving that NDT angles and the RCSP angles are inter-related. Chandler James T[18] compared knee alignment and hind foot alignment pre-operatively and post-operatively found that alignment of the foot before TKR was contributing factor to the hind foot alignment after TKR.Thus, OA correction increases foot arches. Scott Hadley M D[17] found more the severe of knee OA deformity at the foot increases, thus along with correcting the deformities proper balancing of the soft tissue and associated joints is important to avoid mal-alignment, knee instability, premature mechanical failure of TKR components.

The comparison between pre TKR NDT angles and RCSP angles showed a significant moderate to strong correlation in means of NDT and RCSP when correlated between operated and non-operated limb suggesting that change in one limb causes a change in the contralateral limb.[17,27]

As foot arches are dependent on weight bearing thus NDT and RCSP angles in non weight bearing shows insignificant change. The study was carried for a 4 weeks period wherein the foot changes after 4 weeks was not studied with follow up. Ankle exercises weren't included in the conventional TKR rehabilitation protocol to strengthen the plantar fascia and the intrinsic foot muscles nor any orthotic support given to maintain the corrected foot position.

Therefore, based on the study finding it is found that these is significant influences of conventional post TKR protocol on changes in both NDT angles and RCSP angles in weight bearing whereas there is negligible change in NDT angles and RCSP angles in non weight bearing. Hence the study reject null hypothesis.

CONCLUSION

It is concluded that there is significant influence of 4 weeks of conventional post TKR Rehabilitation protocol on improving angles of flat foot that there was retaining of foot arch towards normal angle by increase in navicular angles and decrease in relaxed calcaneal stance phase angle in subjects with unilateral TKR. Therefore implementation of flat foot correction methods in conventional TKR rehabilitation protocol is necessary for long term outcomes of the patient.

Limitations of the study:

The study was carried on one fixed standard protocol. The study was carried for a short period of time up to 4 weeks post surgery. Follow up after 4 weeks of study was not done. Influences of Posture, bony, soft tissue structures were not evaluated. Bilateral TKR were not included in the study. Any particular TKR implant and type of TKR surgery was not studied.

Recommendation for future research:

Randomized controlled trail studying long term follow up is needed. Studies are need to find influences of Posture, bony, soft tissue structures on flat foot following TKR protocols are needed. Further studies can be carried on influences other standard TKR protocol on flat foot angle. Studies considering Bilateral TKR on particular TKR implant and type of approach for TKR surgery on flat foot angles changes following TKR are necessary.

Acknowledgement

Authors were expressing their sense of gratitude's to the people who helped and encouraged them for the guidance and completion of this study. I sincerely acknowledge my indebtedness to Dr. Narendra Vaidya, Orthopedic surgeon, consider myself fortunate for the constant encouragement given for his keen interest and guidance throughout the work who referred subjects for my study.

Conflicts of interest: None

REFERENCES

1. Kim HA, Kim S, Seo YI, Choi HJ, Seong SC, Song YW, Hunter D, Zhang Y. The epidemiology of total knee replacement in South Korea: National registry data. Rheumatology 2008;47:88–91.
2. Mündermann A, Dyrby CO, Andriacchi TP. Secondary gait changes in patients with medial compartment knee osteoarthritis: increased load at the ankle, knee, and hip during walking. Arthritis Rheum. 2005;52(9):2835-44.
3. Vikki Wylde. Persistant pain after joint replacement: Prevalance, sensory qualities & post operative determinant. Journal 2011; 152 (3): 556-572.
4. Pazit Levinger, Hylton B Menz, Adam D Morrow, Julian A Feller, John R Bartlett, Mohammad R Fotoohabadi, Neil Bergman. Changes in foot posture and function following total knee replacement surgery. Journal of Foot and Ankle Research 2012, 5(Suppl 1):P17 http://www.jfootankleres.com/content/5/S1/P17
5. T Miyazaki, M Wada. Dynamic load at baseline can predict radiographic disease progression in medial compartment knee osteoarthritis. Ann Rheum Dis. 2002 ; 61(7): 617–622.
6. Joan E Edelstein. Foot Care for the Aging. Journal of American physical therapy. 1988; 68:1882-1886.
7. Bertani A, Cappello A, Benedetti MG, Simoncini L, Catani F. Flat foot functional evaluation using pattern recognition of ground reaction data. Clinical Biomechanics1999; 14:484-493.
8. Menz HB. Alternative techniques for the clinical assessment of foot pronation.J Am Podiatr Med Assoc.1998;88(3):119-29.
9. Marlene Fransen, Lisa Bridgett, Lyn March, Damian Hoy, Ester Penserga, Peter Brooks. Osteoarthritis in Asia. International Journal of Rheumatic Diseases 2011; 14:113–121.
10. Nilsson M K, Classification of the height and flexibility of the medial longitudinal arch of the foot: Journal of Foot Ankle Research 2012;17(5);3.
11. Shyam Ashok K, Joshi Rajeev, Patil Surendra, Sancheti Parag K, Sancheti K H. Hindfoot alignment variation before and after total knee arthroplasty results of a pilot study. Journal of Orthopaedic and Rehabilitation.2011;1(1):41-43.
12. David Maggie, Orthopaedic physical assessment. edition 5. St. Louis: Elsevier; (2008) pg 867.
13. Soren Sporndly-Nees The Navicular Position Test – A relable measure of the navicular bone position during rest and loading. Int J Sports Phys Ther. 201; 6(3): 199–205.
14. Pazit Levinge: Elsevier. BV. Australia. [Internet].2012.[updated 2012 July 4; Available from: http://www.ncbi.nih.gov/pubmed/22672961.
15. Pezit-Levinger, Hyton B, Jullian A Feller. Changes in foot posture and function following total Knee replacement Surgery. Journal of foot and ankle research 2012; 5: 11-13.
16. Scott Hadley, Joseph Fetto.USA. Journal of foot and ankle surgery 2008. Available from: www.synvasive.com/resources/eLIBRA-Whitepaper-Hardley-Fetto.pdf
17. Chandles J.T, Moskal JT. Evaluation of knee & hindfoot alignment before and after total knee arthroplasy: a prosecptive analysis. J Arthroplasty 2004: 9 (2): 211-216.
18. Steele, J. R., Mickle, K. Julie. & Munro, B. Fat flat frail feet: how does obesity affect the older foot. XXII Congress of the International Society of Biomechanics 2009.
19. A Wleuka. F M Cicuttini. Abnormal biomechanics: a precursor or result of knee osteoarthritis. British Journal of sports medicine 2003; 37: 289-290.
20. Stewart C Morrison. Inter rater reliability of foot posture index (FPI-6) in the assessment of the paediatric foot. Journal of flat foot and ankle research 2009;2(26).
21. S. Brent Brotzman, M D ,Clinical orthopaedic assessment. Edition 2. Pennsylvania: Elsevier (2009); 468-472.
22. Chitrajan S. Ranawat,MD, Amar S. Ranawat. Total knee arthoplasty rehabilitation protocol. The journal of arthroplasty 2003; 18(3): 1.
23. Rasmus G Neilson, Michael S Rathleff, Ole H Simonsen, Henning Langberg. Journal of foot and ankle research [Internet] Denmark. 2009, 2:12, doi:10.1186/1757-1146-2-12. Available form: http://www.jfootankleres.com/content/2/1/12.
24. Michael S, Pinzur, MD , Journal of Foot and ankle research[Internet].2012. Availablefrom:http://lowerextremityreview.com/article/when/foot/ankle/issues/comlicate/knee/surgery.
25. Stephen M. Pribut,DPM. Washington. Gait biomechanics. Available from: http://www.drpribut.com/sports/spgait.html
26. Yi-Wen Chang, Wei Hung. Measurements of Foot Arch in Standing, Level Walking, Vertical Jump and Sprint Start. International Journal of Sport and Exercise Science.2010; 2(2): 31-38.
27. Chun-De Liao, Tsan-Hon Liou, Yu-Yun Huang, Yi-Ching Huang. Effects of balance training on functional outcome after total knee replacement in patients with knee osteoarthritis: a randomized controlled trial. Clinical Rehabilitation March 5, 2013 Available from: http://m.cre.sagepub.com/content/early/2013/03/05/0269215513476722.

How to cite this article:

Smisha Thomas, Vinod Babu. K, Sai Kumar. N, Vikas Kadam V. Influence of Conventional Post Total Knee Replacement Rehabilitation Protocol on Angles of Flat Foot. Int J Physiother Res 2013;05:267-73.