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ORIGINAL ARTICLE

EFFECTIVENESS OF MANUAL PHYSICAL THERAPY AND LOW INTENSITY CYCLE ERGOMETRY IN IMPROVING PAIN, STIFFNESS, PHYSICAL FUNCTION AND FUNCTIONAL EXERCISE CAPACITY IN ADULT WITH OSTEOARTHRITIS KNEE

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ABSTRACT

Background and objective: Manual physical therapy and low-intensity cycle ergometry has strong theoretical basis in treatment and prevention of OA Knee. Physical therapy consists of manual therapy to knee, combined with range of motion and strengthening exercises. Recent advances has shown that cycle ergometry is beneficial in OA knee. Stationary cycling did not increase knee pain in patients with OA knee. The purpose of this study is to find out the effectiveness of manual physical therapy and Low intensity cycle ergometry in OA knee. **Methdology:** 30 subjects with osteoarthritis knee were recruited and divided into groups A and B with 15 subjects in each group after signing an informed consent. Pre test was conducted on "WOMAC" for pain, stiffness and physical function and "Six minute walk test" for functional exercise capacity on both Groups. After a brief demonstration, Group A subjects were subjected to manual physical therapy, low intensity cycle ergometry and supervised exercise program for a period of 4 weeks, 2 sessions per week. After a brief demonstration, Group B subjects were subjected to supervised exercise program for a period of 4 weeks, 2 sessions per week. Post test was conducted on "WOMAC" for pain, stiffness and physical function and "Six minute walk test" for functional exercise capacity on both Groups. **Result:** Based on the statistical analysis, the result of the present study shows that there is statistically significant difference in pain, stiffness, physical function and functional exercise capacity between pre-test and post-test in both experimental and control group. **Conclusion:** Manual physical therapy and low intensity cycle ergometry is effective in improving pain, stiffness, physical function and functional exercise capacity in OA Knee.

Keywords: Osteoarthritis knee, manual physical therapy, low intensity bicycle ergometry, pain, stiffness, functional exercise capacity, womac, 6 min walk test.

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INTRODUCTION

Osteoarthritis (OA) is a long-term chronic disease characterized by the deterioration of cartilage in joints which results in bones rubbing together and creating stiffness, pain, and impaired movement. The disease most commonly affects the joints in the knees, hands, feet, and spine and is relatively common in shoulder and hip joints. In case of OA knee, the ability to raise from chair, stand comfortably, walk and use of stairs will be often limited for those patients. For OA population pain and deconditioning leads to disability. While OA is related to ageing, it is also associated with a variety of both modifiable and non-modifiable risk factors, including: obesity, lack of exercise, genetic predisposition, bone density, occupational injury, trauma, and gender.

Manual physical therapy and low-intensity cycle ergometry has strong theoretical basis in treatment and prevention of OA Knee[15]. Manual therapy programs help patients to regain joint mobility and function[7,9,11]. Physical therapy consists of manual therapy to knee, combined with range of motion and strengthening exercises. Moderate exercise may be a good treatment not only to improve joint symptoms and function but also to improve the knee cartilage glycosaminogly can content in patients of high risk in developing OA. Physical therapy for knee OA has historically focused on improving strength of the quadriceps and hamstrings.

Increasing muscled strength may reduce the loads applied to knee joint during functional movements and also improve the stability of the knee joint. Instability is a key symptom of patients with knee OA and has been found to be the reason patients discontinue some activities. Knee joint instability has been shown to decrease with the use of resistances performed under the supervision of a trained physical therapist followed by a home program[2,6]. Some studies has shown that combination of manual physical therapy and supervised exercise yields functional benefits for patients with OA knee [4]. Some studies has shown that cycling may be considered as an alternative exercise modality for patient with knee OA. Low intensity cycling was effective as high intensity cycling in improving function and gait, decreasing pain and increasing aerobic capacity.[1,3,5,16] Most aerobic exercise trials have used walking as the primary modality for exercise. Stationery cycling is another common exercise modality that has been shown to produce aerobic training effects[19]. However, its effectiveness among people with OA has not been studied because of the belief that repetitive motions cause further injury. Kinesiological studies suggests that the force generated at the knee are no greater for cycling than walking therefore it would appear to be an alternative modality for patients with knee OA[17].

A few studies are available for low intensity cycle ergometry for treating OA knee. So this study was to find the effectiveness of manual physical therapy and low intensity cycle ergometry in improving pain, stiffness, physical function and functional exercise capacity in adults with OA knee.

Rationale of the Study: Active and passive range of motion exercise is considered as an important part of rehabilitation programs for patients with OA. Physical therapist frequently use manual therapy procedures as part of comprehensive rehabilitation programs to help patients regain joint mobility and function. Studies shows that Physical therapy consisted with manual physical therapy to the knee, hip, ankle and lumbar spine combined with range of motion, strengthening and cardio- vascular exercises are effective in decreasing pain, stiffness and functional limitations. On the other hand recent advancements have shown that cycle ergometry has been proved to be beneficial in OA knee.

Aim of the Study: The aim of the study was to find out the effectiveness of manual physical therapy and low intensity cycle ergometry in improving pain stiffness, physical function and functional exercise capacity in OA knee.

Objective of the study:

1. To determine the effectiveness of manual physical therapy and low intensity cycle ergometry in improving pain, stiffness and physical function by measuring WOMAC score in subjects with Osteoarthritis knee.
2. To determine the effectiveness of manual physical therapy and low intensity cycle ergometry in improving functional exercise capacity by measuring six minute walk test in subjects with Osteoarthritis knee.

Hypothesis

Null hypothesis: There will be no significant difference in pain, stiffness, physical function and functional exercise capacity in patients with Osteoarthritis Knee after the application of Manual physical therapy and low intensity cycle ergometry.

Alternative hypothesis: There will be significant difference in pain, stiffness, physical function and functional exercise capacity in patients with Osteoarthritis Knee after the application of Manual physical therapy and low intensity cycle ergometry.

METHODOLOGY

Study design: Pre Vs. post- test experimental design.

Study setting: Patients with OA Knee diagnosed and referred by a consultant orthopaedician from Outpatient department, Bethany Navajeevan college of Physiotherapy .

Sampling design: Purposive sampling method used to select samples for this study.

Sample size: 30 (15 in experimental group & 15 in control group)

Inclusion criteria:

- Both males and females
- Knee pain age 50 years or older, morning stiffness for more than 30min and bony enlargement.[15]
- crepitus on active ROM[15]
- Positive radiography
- Have no physical impairment unrelated to the knee that would prevent safe participation in timed six minute walk test or any other aspect of the study

Exclusion criteria:

- Patient had surgical procedures on either lower extremity in past 6months[15]
- Non co-operative and psychological patients.
- Pregnant ladies
- Patients with systemic rheumatoid disease, history of unstable metabolic disease and neurological disorders
- Cardiopulmonary condition that precluded participation in aerobic exercise.

Duration of the study: The study was conducted over a period of 1 year.

Outcome measure: WOMAC for pain, stiffness and physical function , Six Minute Walk test for functional exercise capacity [8, 12, 20].

Statistical analysis: Wilcoxon signed rank test, Mann-Whitney U test.

Procedure: Based on the inclusion criteria, 30 subjects with osteoarthritis knee were included in the study. The subjects were divided into two groups, i.e., Group A and Group B with 15 subjects in each group.

Pre- test was conducted on "WOMAC" for pain, stiffness and physical function and "Six minute walk test" for functional exercise capacity on both Group A and Group B.

Once the subjects were classified into these groups, an informed consent collected from them. After a brief demonstration about manual physical therapy, low intensity cycle ergometry and supervised exercise program Group A subjects were subjected to manual physical therapy, low intensity cycle ergometry and supervised exercise program for a period of 4 weeks, 2 sessions per week.

After a brief demonstration about supervised exercise program Group B subjects were subjected to supervised exercise program for a period of 4 weeks, 2 sessions per week. Post-test was conducted on "WOMAC" for pain, stiffness and physical function and "Six minute walk test" for functional exercise capacity on both Group A and Group B.

Supervised Exercise Program Procedure

Stretching Exercises

Exercises	Measure
1. Standing calf stretch	3 repetitions, 30sec hold
2. Supine hamstring stretch	3 repetitions, 30 sec hold
3. Prone quadriceps stretch	3 repetitions, 30sec hold

Range of Motion Exercises

Exercises	Measure
1) In long sitting position knee mid flexion to end range extension	Two 30sec bouts with 3sec hold at end range
2) In long sitting position knee mid flexion to end range flexion	Two 30sec bouts with 3sec hold at end range

Strengthening Exercises

Exercises	Measure
1) Static quadriceps sets in knee extension	One set of 10 repetitions with 6sec hold
2) Closed chain progression	
a. Standing terminal knee extension	One 30sec bout, increase resistance as tolerated
b. Seated leg press	One 30sec bout, increase resistance as tolerated

Manual Physical Therapy of knee joint:

- **Distraction:** Patient in high sitting, the therapist hold the lower leg at the ankle and pulls in a downward direction
- **Tibiofemoral Anterior Glide:** Patient in supine lying, kneeflexed, foot resting on couch. The therapist stabilizes the foot of patient by partially sitting on foot then holds the upper part of lower leg by cupping with both the hands and pulls the tibia forwards.
- **Tibiofemoral Posterior Glide:** Patient in supine lying, kneeflexed, foot resting on the couch. with one hand the therapist stabilizes the lower end of the femur and with the other pushes the upper end of tibia in a posterior direction.
- **Patellofemoral Joint Mobilization:** supine with knee supported by table, wedge, or towelroll; mobilizing thumb and index finger placed along patellar border oriented to direction of mobilization. Apply a medially, laterally, superiorly, or inferiorly directed force to the patella.

Soft Tissue Manipulations:

- **Efflurage**: The knee is effluraged by crossing hands above the patella, drawing them backwards on each side of it until the heels of your hands meet below the patella then turning your hands to allow fingers to pass behind the knee over the popliteal fossa.
- **Kneading Round The Knee:** Whole handed kneading round the knee should extend from just above the superior margin of the synovial membrane to a hand width below the knee so that you encompass all the structures in the region. Start with both hands on the anterior aspect with the heels of the hands touching above the patella, work down, letting the heels of hand divide round the patella to avoid working over it, let the heels of hands meet again below the patella. Next insert each hand from the opposite side under the lower thigh until your finger overlap. Now work down on this aspect, covering the same level as in the previous line of work.
- **Thumb Kneading Round The Patella:** Use the maximum length of the thumb and work either with thumbs one on each side of

the patella i.e., starting near each other and dividing round the bone margin. With both thumbs working adjacent and alternately round every aspect of the patella margin.

- **Finger Kneading At The Knee:** Use finger tips to work on each side of the bony areas of the knee with thumbs resting on adjacent area. Place finger tips in a linear formation on first one side then the other, on the tendon of the hamstrings at the knee so that one of the hand is on biceps femoris and the other on the semimembraneous and semitendinous tendon[6].

RESULT

Comparison of pre test vs post test scores of womac in experimental group (Group A)

GROUP	N	Minimum	Maximum	Mean	Std. Deviation	Mean Difference	z value	p value
PRE TEST	15	32	52	40.60	5.552	25.80	-3.41	0.000
POST TEST	15	11	22	14.80	3.668			

Table: 1 Comparison of pre- test vs post- test scores of womac in experimental group (group A)

COMPARISON OF PRE TEST VS POST TEST SCORES OF WOMAC IN CONTROL GROUP (GROUP B)

GROUP	N	Minimum	Maximum	Mean	Std. Deviation	Mean difference	Z value	P value
PRE TEST	15	36	50	40.73	3.634	13.93	-3.418	0.000
POST TEST	15	25	28	26.80	0.862			

Table: 2 Comparison Of Pre Test Vs Post Test Scores Of Womac In Control Group(Group B)

Comparison between post test scores of womac in experimental group vs post test scores of WOMAC in control group

	GROUP	N	Mean Rank	Sum of Ranks	Mann Whitney U Test	SIGBNIFICANCE (p)
POST WOMAC	A	15	8.00	120.00	0.000	0.000
	B	15	23.00	345.00		
	Total	30				

Table: 3 Comparison between post test scores of womac in experimental group versus post test scores of WOMAC in control group

COMPARISON OF PRE TEST VS POST TEST SCORES OF 6MIN WALK TEST IN EXPERIMENTALGROUP (GROUP A)

GROUP	N	Minimum	Maximum	Mean	Std. Deviation	MEAN DIFFERENCE	z value	P value
PRE TEST	15	140	400	248.00	63.381	83.33	-3.415	0.000
POST TEST	15	230	450	331.33	64.239			

Table: 4 Comparison of pre test vs. post test scores of 6min walk test in experimental group (Group A)

Comparison of pre test vs post test scores of 6min walk test in control group (Group B)

GROUP	N	Minimum	Maximum	Mean	Std. Deviation	Mean difference	z value	p value
PRE TEST	15	150	300	222.00	49.886	3.33	-0.829	0.453
POST TEST	15	170	310	225.33	46.116			

Table: 5 Comparison of pre testvs post test scores of 6 min walk test in control group (Group B)

Comparison between post test scores of 6 min walk test in experimental group vs post test scores of 6 min walk test in control group

GROUP		N	Mean Rank	Sum of Ranks	Mann Whitney U Test	SIGNIFICANCE (P)
POST 6 min Walk Test	A	15	21.50	322.50	22.5000	0.000
	B	15	9.50	142.50		
	Total	30				

Table: 6 Comparison between post test scores of 6 min walk test in experimental group vs. post test scores of 6min walk test in control group.

The result of the present study shows that there is statistically significant difference in pain, stiffness, physical function and functional exercise capacity between pre-test and post-test in both experimental and control group. Experimental group shows greater improvement in pain, stiffness and physical function while measuring WOMAC and functional exercise capacity while measuring 6min. walk test than control group in subjects with OA Knee.

DISCUSSION

The purpose of the study was to determine the effectiveness of manual physical therapy and low intensity cycle ergometry in patients with OA knee. Based on the inclusion criteria, 30 subjects with osteoarthritis knee wereincluded in the study. The subjects were divided into two groups, i.e., Group A and Group B with 15 subjects in each group.Pre- test was conducted on "WOMAC" for pain, stiffness and physical function and "Six minute walk test" for functional exercise capacity on both Group A and Group B.Once the subjects were classified into these groups, an informed consent collected from them. After a brief demonstration about manual physical therapy, low intensity cycle ergometry and supervised exercise program, Group A subjects were subjected to manual physical therapy, low intensity cycle ergometry and supervised exercise program for a period of 4 weeks, 2 sessions per week. After a brief demonstration about supervised exercise program, Group B subjects were subjected to supervised exercise program for a period of 4 weeks, 2 sessions per week. Post- test was conducted on "WOMAC" for pain, stiffness and physical function and "Six minute walk test" for functional exercise capacity on both Group A and Group B. All subjects well tolerated the interventions given and no one was dropped out of the study.Wilcoxons signed rank test and Mann-Whitney U test were used as statistical tools to reach a conclusion.

Courtney C A et al (2016)conducted a study to examine the effect of joint mobilization on impaired conditioned pain modulation in patients with OA knee by applying joint mobilization.[1] 40 individuals with moderate or severe knee OA identified 29 with impaired continuous passive movements. These subjects were randomized to receive 60 min of knee joint mobilization on manual cutaneous input only one week apart. Deep tissue hyperalgesia was examined through pressure pain thresholds bilaterally at the knee medial joint line and the hand at baseline post intervention and post continuous passive movements

testing. Further vibration perception threshold was measured at the medial knee epicondyle at baseline and post continuous passive movement testing and concluded that conditioned pain modulation was enhanced following joint mobilization demonstrated by a global decrease in deep tissue pressure sensitivity. Joint mobilization may act through enhancement of descending pain mechanism in patients with painful knee OA. Kathleenkline Mangione et al (1999)Conducted a study on people with OA knee experiencing pain and deconditioning that lead to disability and this study was to find the effects of high intensity and low intensity stationary cycling on functional status gait overall and acute pain and aerobic capacity were examined. For that 39 adults (71+/- 69 years old) with complaints of knee pain and diagnoses of OA where randomized to either a high intensity (70% HRR) or low intensity (40% HRR) exercise group for 10 weeks of stationery cycling participate cycled for 25min 3 times per week.

Before and after the exercise intervention they completed the arthritis impact measurement scale for overall pain assessment underwent timed chair raise, 6min walk test, gait and graded exercise treadmill test.[21] Acute pain was reported daily with Visual Analogue Scale and WOMAC score. Analysis of variance revealed that participants in both groups significantly improved in the timed chair raise in the 6 min walk test. The study concluded that low intensity cycling was as effective as high intensity cycling in improving function and gait, decreasing pain and improving aerobic capacity. The result of the present study supports the previous studies.

Based on the statistical analysis, in experimental group(Group A). The pre- test mean value with standard deviation of WOMAC test was 40.60±5.552 with minimum value of 32 and maximum value of 52.The post- test mean value with standard deviation of a 6 min walk test was 14.80±3.668 with minimum value of 11 and maximum value of 22.The mean difference was 25.80, z value was -3.41 and p value was 0.000. The result of this study shows that there is statistically significant difference between pretest and posttest values of WOMAC test in experimental group. Based on the statistical analysis, in control group B the pre- test mean value with standard deviation of WOMAC test was 40.73±3.634 with minimum value of 36 and maximum value of 50.The post- test mean value with standard deviation of a 6 min walk test was 26.80±0.862 with minimum value of 25 and maximum value of 28.The mean difference was 13.93, z value was -3.418 and p value was 0.000. The result of this study shows that there is statistically significant difference between pretest and posttest values of WOMAC test in control group.While comparing Group A and Group B, the mean rank for group A was 8.00 and group B was 23.00. The sum of the ranks for group A was 120.00 and for group B was 345.00.

Mann Whitney U value was 0.000, the P value was 0.000. The result of the study shows that there is statistically significant difference between the post- test mean rank of WOMAC in group A and group B. The post- test mean rank of WOMAC shows that experimental group (group A) shows significant improvement in functional exercise capacity than in control group. (Group B). Therefore the study rejects the null hypothesis and accepts the alternate hypothesis.

Based on the statistical analysis, in experimental group A the pre- test mean value with standard deviation of a 6 min walk test was 248.00±63.381with minimum value of 140 and maximum value of 400.The post- test mean value with standard deviation of a 6 min walk test was 331.33±64.239 with minimum value of 230 and maximum value of 450.The mean difference was 83.33, z value was 3.415 and p value was 0.000. The result of this study shows that there is statistically significant difference between pretest and posttest values of 6 min walk test in experimental group (Group A.) Based on the statistical analysis, in control

group B the pre- test mean value with standard deviation of a 6 min walk test was 222.00±49.886 with minimum value of 150 and maximum value of 300.The post- test mean value with standard deviation of a 6 min walk test was 225.33±46.116 with minimum value of 170 and maximum value of 310.The mean difference was 3.33, z value was -0.829 and p value was 0.453. The result of this study shows that there is statistically significant difference between pretest and posttest values of 6 min walk test in control group.While comparing Group A and Group B, the mean rank for group A was 21.50 and group B was 9.50. The sum of the ranks for group A was 322.50 and for group B was 142.50. Mann Whitney U value was 22.500, the P value was 0.000.

The result of the study shows that there is statistically significant difference between the post- test mean rank of 6 minute walk test in group A and group B. The post- test mean rank of 6 minute walk test shows that experimental group (group A) shows significant improvement in functional exercise capacity than in control group. (Group B).Therefore the study rejects the null hypothesis and accepts the alternate hypothesis. Pain is decreased by decreasing the compressive forces on the joint (distraction techniques). Gating of pain impulses occurs when movement of periarticular tissue being manipulated stimulates fast-conducting large-diameter proprioceptive nerve fibers that block the transmission of slow-conducting small-diameter pain fibers, thus minimizing the transmission of pain impulses to the brain.

Reducing pain have a secondary effect on muscle relaxation. Relaxation of periarticular muscles also is achieved by the stimulation of joint receptors with joint manipulation techniques. Joint receptors protect the joint from damage incurred by going beyond the physiologic ROM. During immobilization Intracellular water content decreases. This leads to decrease in the distance between fibers constituting the joint capsule. This results in increase in the fiber cross link formation, which produces adhesions. Also adhesions form between synovial folds. Formation of new collagen tissues, and if movement does not occur between these tissues, additional cross-linking will occur. Production of fibro fatty connective tissue proliferation within the joint, which is transformed into scar tissue. Strength of collagen tissue decreases. Joint manipulation reverse these changes by promoting movement between capsular fibers. This is believed to result in an increase in interstitial water content and inter fiber distance. By promoting movement between capsular fibers through the repetitive manipulation of joint structures, synovial tissue will stretch in a selective manner, causing gradual rearrangement of old collagen tissue with a reduction of cross-link formation and development of parallel fiber configuration in new collagen tissue. More aggressive manipulation techniques break adhesions in joint capsule and in the synovial folds. Manipulation increases the length of the capsular fibers. It also break intracapsularfibrofatty adhesions. Joint manipulation lengthens thickened capsular tissue and reduces capsular adhesions. All of these responses increase the arthrokinematic motion at a joint.

A number of investigators have studied changes in pain perception following cycling exercise using noxious dental pulp stimulation techniques.[10,13,14] Pertovaara et al. assessed changes in dental pain thresholds during and following exercise at different intensities. Dental pain thresholds were determined with a Bofors Pulp Tester, in which a cathode was attached to an upper tooth, and assessments were completed before, during and following exercise. Four different levels of exercise (50, 100, 150 and 200W) were completed on a bicycle ergometer by men.

Workloads were increased stepwise without rest between the different levels,and each work period lasted 8 minutes. It was reported that dental pain thresholds tended to increase with the increasing workloads. However, a

significant increase in pain thresholds was only evident at the 200W workload. Dental pain thresholds remainedelevated 30 minutes following exercise.Kathleen Kline Mangione et al (1999) Conducted a study on people with OA. The purpose of the study was to find the effects of high intensity and low intensity stationary cycle ergometry in older adults with knee osteoarthritis. Walking performance in these subjects improved after 10 weeks of cycling. Subjects were able to increase their range of walking speeds by walking slower when instructed to walk as slowly aspossible and walk faster when instructed to walk as quickly as possible .The increase in range of walking speed may reflect improvement in the "reserve capacity" of walking.

The aging cardiopulmonary system exhibits decreased maximal VO2, cardiac output, and heart rate; the decreased maximal values result in decreased reserve capacity. Older persons must function at a greater percentage of their maximum during routine activities. In gait, the increase infast walking and slow walking speeds suggests that cycling may have increased the reserve capacity by affording a broader range of walking performance[2].

Based on the statistical analysis, the result of the present study shows that there is statistically significant difference in pain, stiffness, physical function and functional exercise capacity between pre-test and post-test in both experimental and control group.

Experimental group shows greater improvement in pain, stiffness and physical function while measuring WOMAC and functional exercise capacity while measuring 6min. walk test than control group in subjects with OA Knee. Thus the study concludes that manual physical therapy and low intensity cycle ergometry is effective in improving pain, stiffness, physical function and functional exercise capacity in OA Knee [18,19, 21].

Limitations

- No long term follow ups
- Small sample size
- WOMAC pain score was in English and translation was needed for illiterate people.
- Blinding of therapist was not done

Recommendations

- Studies have to be conducted on more diverse population.
- Randomized control trials have to be done.
- Further research is recommended in a large population.
- Further research shall be done by using other methods to measure pain, stiffness and physical function and functional exercise capacity.
- WOMAC scores translated in Malayalam language shall be used for further research.

CONCLUSION

Based on the statistical analysis, the result of the present study shows that there is statistically significant difference in pain, stiffness, physical function and functional exercise capacity between pre-test and post-test in both experimental and control group. Experimental group shows greater improvement in pain, stiffness and physical function while measuring WOMAC and functional exercise capacity while measuring 6min. walk test than control group in subjects with OA Knee. After analyzing this study, the following conclusion was drawn: Manual physical therapy and low intensity cycle ergometry is effective in improving pain, stiffness, physical function and functional exercise capacity in OA Knee.

REFERENCES

1. Courtney C A et al. Joint mobilization enhances mechanisms of conditional pain modulation, in individuals with osteoarthritis knee. Journal for Orthopedics and sports physical therapy. April 2016.
2. Augusto G Zapicoet al. Predicting peak oxygen uptake from the 6 minute walk test in patients with pulmonary hypertension. JCRP journal, 2016.
3. Regnaux J P et al. High Intensity versus low intensity physical activity or exercise in people with hip or knee Osteoarthritis. 2014.
4. Fransen et al. Exercise for Osteoarthritis of the Knee. Cochrane data base systems review. May 2013.
5. Cynthia L Johnson. Comparison of pulse oximetrymeasures in a healthy population. Medsurg. March- April 2012;21: 2.
6. Amanda. J Salacinski et al. The effects of group cycling on gait and pain- related disability in individuals with mild to moderate osteoarthritis. Journal of Orthopedic and sports physical therapy. December 2012.
7. Mariette J Jansen et al. Strength training alone, exercise therapy alone and exercise therapy with passive manual mobilization each reduce pain and disability in people with knee osteoarthritis: a systemic review. Journal of physiotherapy. 2011; 57: 11-20.
8. Peter Soderman and HentricMalchaer. Validity and reliability of WOMAC OA Index; Self-administered disease specific questionnaire. 8 July 2009.
9. Denny Moss, Kathleen Sluka et al. The initial effect of knee joint mobilization on osteoarthritic hyperalgesia. Manual therapy. May 2007;12: 109- 118.
10. Moss P et al. The initial effects of knee joint mobilization on osteoarthritis hyperalgesia, 2006.
11. Lippincott Williams and Wilkins. Hall & Brody. Therapeutic Exercise: Moving Toward Function. 2nd Edition; 2005.
12. F. Salaffi et al. Reliability and validity of the Weterrn Ontario and Mc Master Universities (WOMAC) Osteoarthritis Index in patients with osteoarthritis of the knee. Osteoarthritis research society international. 2003; 11, 551- 560.
13. Marlene Fransen, Sara Mc Connell et al, Therapeutic exercise for people with OA of hip or knee- A systematic review. The Journal of Rheumatology, 29 August 2002; 1737- 1748.
14. M. Fransen, J. Crosbie et al. Physical therapy is effective for patients with OA Knee- A randomized control trial. Journal or Rheumatology. 28 January 2001; 156-164.
15. Gail D Deyle et al. Effectiveness of manual physical therapy and exercise in Osteoarthritis of knee. Annals of internal medicine. February 2000; 132: 3.
16. Kathleen Kline, Mangione et al. The effects of high intensity and low intensity cycle ergometry in older adults with knee osteoarthritis. Journal of Gerontology Medical Sciences. 1999; 54A: M184- M190.
17. E.M. Roos, m. Klassbo et al. Womac osteoarthritis index; Reliability, validity and responsiveness in patients with arthroscopically assessed OA. Scandinavian Journal of Rheumatology. 1999; 28: 210-215.
18. Nancy. D. Harada et al. Mobility related function in older adult; Asssessmaent with a 6min. walk test. Archives of physical medicine and rehabilitation. July 1999; 80: 837-841.
19. Gordon H Guyatt et al. The 6min Walk test: a new measure of exercise capacity in patients with chronic heart failure. Canada

medicine association journal. April 1985; 132.

20. Bellany N et al. Validation study of WOMAC; A healthy status instrument for measuring clinically important patient relevant outcomes to anti-rheumatoid drug therapy in patients with osteoarthritis of hip or knee.Journal of Rheumatology. 1985; 1833- 1840.
21. Roberta E et al. The reliability and validity of six minute walk test as a measure of physical endurance in older adults. Journal of aging and physical activity. 1998; 6:363-375.

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