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Comparing open kinetic chain with closed kinetic chain exercise on quadriceps strength and functional status of women with osteoarthritic knees

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Abstract. *Aim*. The objective of this study is to show the effectiveness of close kinetic chain exercise (CKC) over open kinetic chain exercise (OKC), on female osteoarthritic knee. *Method*. Thirty female osteoarthritic patients were selected on the basis of their inclusion and exclusion criteria and they were randomly divided into two groups of 15 patients in each group. Group A was provided with CKC while group B was given OKC exercises. The readings were taken on day 0 and day 35 during the 5 weeks study. *Result*. The result of the effectiveness of CKC over OKC is obtained through WOMAC scale and Strain gauge. Through these two scales the strength and functional activity of the quadriceps muscle is evaluated. *Conclusion*. The study shows that closed kinetic chain exercises are more effective than open kinetic chain exercises on female osteoarthritic knees.
Key words*: knee, osteoarthritis, functional status, physiotherapy, exercise*.

Introduction

Osteoarthritis (OA) of the knee is an active disease process involving cartilage destruction, subchondral bone thickening and new bone formation. Radiographic appearance has traditionally been the corner stone of diagnosis because the effects of the pathological processes can be identified as features on X-ray; joint space narrowing, subchondral sclerosis and osteophyte formation (1).

Osteoarthritis in men and women older than 65 are reported to be 80 % and approximately one third of these are symptomatic (2). Clear prevalence patterns emerge from most epidemiological studies of osteoarthritis and increases with age and sex differences are evident.

After about 50 years of age women are more affected with hand, foot, knee OA then men (3).

Individuals with knee OA typically have knee pain, joint stiffness, deficits in proprioception, decrease in muscle strength. Quadriceps femoris muscle weakness have been demonstrated to correlate with knee pain and functional disability (4).

Osteoarthritis of the knee is the most common cause of chronic disability among the elderly. Quadriceps muscle weakness is common in patients with knee in whom it is widely believed to be due to disuse atrophy, consequent to reduction in loading of the extremity because of joint pain (5).

Physiological evidence indicates that there is a 30-40% decline in isometric forces and approximately 18% reduction in muscle mass between second and seventh decade of life. The proximal muscles of the lower limb have been to be especially affected by muscle fiber atrophy and decline in maximum strength during loading (6).

Guidelines for managing OA recommended a combination therapy of physiotherapy and pharmacological treatments. The effect of quadriceps home exercises when compared NSAID's shows exercises have slightly better effect in knee OA than NSAID's (7).

Primary goal of OA is to relieve pain, improve functional status, maintain strength, range of motion, minimize deformity and instability. Physical agents i.e. short wave diathermy (SWD), transcutaneous electrical nerve stimulator (TENS), ultrasound (US) and hot pack (HP) are non invasive modalities to control both acute and chronic pain (8).

For treatment of various knee disorders, muscles are trained in open or closed kinetic chain tasks.

Coordination between the heads of quadriceps muscles important for stability and optimal joint loading for both the tibiofemoral and patellofemoral joint. There is considerable debate regarding the efficacy of OKC and CKC exercises for increased strength and control of knee muscles (9). Some authors conclude that both OKC and CKC programs lead to an equal long term functional outcome (10).

Physical treatment modalities are widely prescribed together with exercises. However there is no agreement which modality will be better when combined with exercises (11).

Exercise and physical agents can reduce pain and improve function and health status of the patients with knee OA. Combined exercise therapy with physical agents increase the effectiveness of exercise (12). Most of the previous researches on OA have compared exercises alone or physical agents alone. In this research the combined effect of exercises along with physical agent is considered.

Material and Method

Thirty female subjects with OA aged in between 50-70years are included in study.

Inclusion criteria: subjects with clinical and radiological criteria for diagnosis of OA; mean age 50-70 years; clinical presentation of unilateral OA; ability to walk at least 100m on an uneven surface; full or near full passive ROM at each knee.

Exclusion criteria: patients not fulfilling Inclusion criteria; patients with previous history of knee surgery; lower extremity arthroplasty; intra articular injection of hyaluronic acid/steroids in last six months.

Sampling. The subjects were screened first on basis of demographic data and fitted according to inclusion criteria and informed consent was taken from the patients and explained the procedure in detail. The subjects were then randomly selected for group A and group B.

Instruments and tools used. Equipments: Strain gauge, hydrocollateral pack, stepper, rowing machine, mini Trampoline (fig 1), stationary bicycle (fig 2)

Procedure. Design of study: comparative study. Methodology: 30 female patients with OA knee were selected on basis of inclusion criteria and divided into two groups with 15 patients in each group, group A (OKC and Hot pack) and group B (CKC and hot pack). Patients were randomly assigned to two groups of 15 patients each.

Patients were evaluated before and after the treatment. Demographic data including age, body weight, height and BMI were obtained. BMI was calculated by weight divided by height as kg/square meter. During the physiotherapy management hot pack was applied around knee for 15min in sitting position with knee extended. After treatment with hot packs, patient perform individual warm-up exercises on stationary bicycle for 20 cycles/minute for 5 minutes before undergoing therapeutic exercises. Then the therapeutic effects were evaluated with respect to pain, disability, function and muscle strength by using Strain gauge and WOMAC osteoarthritic scale. The effects were measured on 0 day and 35^{th} day. Participants were instructed to discontinue any medications and not to start any therapies for knee OA during 5 week study.

Therapeutic OKC exercise program: patient in supine position, short arc movements from 10 degree of knee flexion to terminal extension, leg adduction exercises in lateral decubitus position (fig 1), maximal static quadriceps contractions (quadriceps setting) with the knee in full extension (fig 2).

*Therapeutic CKC program: s*eated leg press, double or single one third knee bend, rowing machine exercise (fig 3), step up and down exercise, progressive jumping exercise on mini trampoline, stationary biking

Data analysis. Data analysis was done using SPSS-7.0 software package. The values collected were that for the dependent variables – measurement of quadriceps strength and WOMAC score. General demographic data was also analyzed (i.e. age, weight, height and BMI and expressed in mean and standard deviation); *t* test was used to compare the difference in mean and S.D between group A and group B. Variables are then compared between and within the group.

Figure 1. Instructing patient about leg adduction exercise

Figure 2. Patient doing quadriceps isometric contraction

Figure 3. Patient doing CKC on rowing machine

Results

Thirty female subjects (N=30) divided into two groups i.e. group A (N=15) and group B (N=15) were evaluated on day 0 and day 35 for dependent variables (e.g. quadriceps strength and WOMAC was evaluated on day 0 and day 35). General demographic data was obtained with respect to age, weight, height and BMI.

On observation it was found that there was no significant difference between group A and group B for demographic data.

In group A (N=15) the mean age was 60.20 (SD=7.24) and for group B, the mean age was 61.27 (SD= 5.36) with a *t* value of 0.325, which is not significant. Similarly, the *t* value for weight, height and BMI were 0.27, 0.06 and 0.11 respectively and these are all not significant. Thus show that there is no difference between the patients of group A and group B. (table I and figure 4)

Comparison of WOMAC between groups A and B

The mean of group A at 0 day was 63.7 and standard deviation on 0 day was 7.2. While mean of group B on 0 day was 64.8 and standard deviation on 0 day was 5.9. The mean value of group A on 35th day was 61.6 and standard deviation was 7.2. While mean value of group B on 35th day was 55.7 and standard deviation was 6.5. The *t* value by applying the independent *t* test was obtained as 2.336. The *p* value obtained by the independent t test was 0.027 which is a significant value, when the level of significance is 0.05. (table II and figure 5)

Comparison of quadriceps strength between the groups. In group A, the QS at 0 day was 49.12 while SD at 0 day was 8.72. The QS on 35th day was 50.48 and the SD on 35th day was 8.65.

In group B, the QS mean on 0 day was 49.29 and standard deviation on 0 day was 7.10. The QS mean on 35th day was 55.24 and standard deviation on 35th day was 5.67.

The *t* value for group A was 0.33 while *t* value for group B was 0.008. *t* value showing a comparison between group A and group B was 0.004, which is a significant value and shows that CKC is more effective than OKC. (table III and figure 6)

Table I. Comparison of Age, Weight, Height and BMI between two groups

Background variables	Group A N=15		Group B N=15		*t* value
	Mean	S.D	Mean	S.D	
Age	60.20	7.24	61.27	5.37	0.32 NS
Weight	74.40	12.50	76.87	8.59	0.27NS
Height	1.59	0.05	1.57	0.04	0.06NS
BMI	29.32	4.79	31.45	4.28	0.11NS

SD - Standard Deviation; NS = not significant

Table II. Comparison of WOMAC between two groups

WOMAC	GROUP A (N=15)		GROUP B (N=15)		*t* VALUE	*p* VALUE
WOMAC 0	MEAN	S.D.	MEAN	S.D.	2.336	0.027 S
	63.7	7.2	64.8	5.9		
WOMAC 35	61.6	7.2	55.7	6.5		

WOMAC 0= WOMAC score on 0 day; WOMAC 35=WOMAC score on 35 day;
S=significant; SD = Standard Deviation

Table III. Comparison of QS between two groups

Quadriceps Strength	Group A N=15		Group B N=15		*t* value
	Mean	S.D	Mean	S.D	
QS0	49.12	8.72	49.29	7.1	0.04 S*
QS35	50.48	8.65	55.24	5.67	

QS0= Quadriceps Strength at 0 day; QS35= Quadriceps Strength at 35 day
*= significant at 0.05 level; N= number of patients in each group

Figure 4. Comparison of age, weight, height and BMI between groups

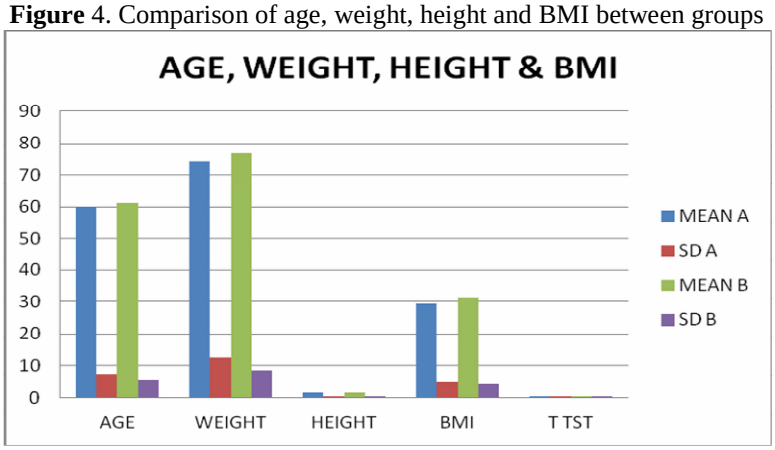


Figure 5. Comparison of WOMAC between groups

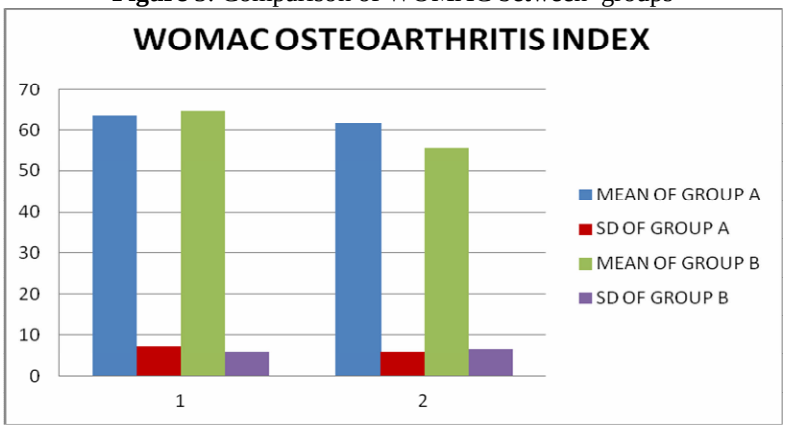
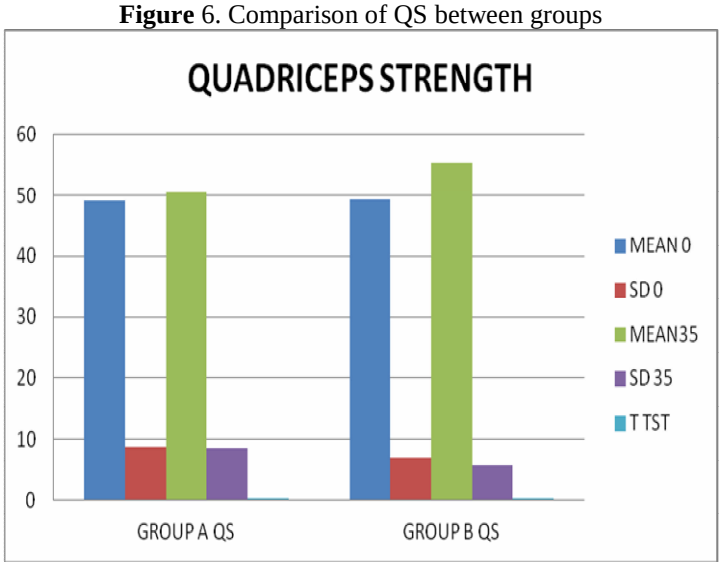


Figure 6. Comparison of QS between groups



Discussion

The primary goal of this study was to test the hypothesis that comparative effect of OKC and CKC along with hot pack on the quadriceps strength and functional status of women with osteoarthritic knees. Subjects included in the study had similar baseline values of mean age, weight, height and BMI and there are no significant differences between them.

Overall results of the study indicate that CKC exercises along with hot pack have more significant effect than OKC exercises with hot pack on the quadriceps strength and therefore contribute to the functional outcome. Group B showed greater improvement in muscle strength and hence the results for group B are statistically significant.

Osteoarthritis is a common progressive health problem among adults. It is estimated that 80% of the adults at or over the age of 65 years exhibits radiographic evidence of OA (13). Osteoarthritis increases with age and sex specific differences are evident. After about 50 years of age women are more often affected with hand, foot and knee OA than men (3). Osteoarthritis is the most common condition affecting the synovial joints. OA of the knee causes substantial pain and disability among elderly, resulting in a significant burden on healthcare provision (14). Knee OA at the baseline was defined as the presence of grade 1+ osteophyte or JSN (joint space narrowing) in at least one of the four compartments(lateral or medial , right or left knee (15). The development and progression of OA is multifactorial with quadriceps weakness being one of the main factors that is modified by resistance training according to this review (16).

Recently, Andriacihi et al. suggested that the initiation of knee OA is associated with the kinematic change in the tibiofemoral load bearing areas where cartilage is not accustomed to such loads and break down (17). Multiple factors play a role in the etiology of muscle weakness. In addition to pain and disuse atrophy, reduced quadriceps activation has been suggested to contribute osteoarthritis (18). Sharma et al reported that varus or valgus laxity and malalignment may influence the relationship between quadriceps strength and progression of tibiofemoral arthritis (19). In the unloaded state, varus/valgus stability is provided by the ligaments, capsule, and other soft course, condylar geometry and tibiofemoral contact forces at the joint interface generated by muscle activity and gravitational forces (20).

Quadriceps weakness is clinical important because it is associated with impaired functional performance and disability. As in OA in patients with rheumatoid arthritis with lower limb involvement we found that quadriceps weakness is associated with objective and subjective disability and intervention that increase quadriceps strength would therefore expected to decrease disability (21). For instance Steultjens and colleagues reported that decreased quadriceps femoris muscle structure accounted for 15-20% of the lower extremity functional disability and for 5% of the knee pain associated with OA. Therefore one aim of physical therapy

intervention for patients with OA to increase strength of the musculature surrounding the knee joint (4). Self reported knee pain, stiffness and difficulty in physical function will be measured using the WOMAC osteoarthritic Index a valid, reliable and responsive disease specific instrument (22). Exercises that strengthen the quadriceps leads to decrease in knee pain (8). There is high quality evidence that exercise reduces pain and improves physical function in patients with knee OA type of exercise e.g improving muscle strength, gait, ROM and stability varied widely both within and across sessions.

Muscle strength exercises were most commonly used (90%) (23). Huang and coworkers compared the Therapeutic effects of different muscle strengthening (9) (isotonic, isometric and isokinetic) exercise on the functional status of patients with knee OA (8). Open kinetic chain leg extension exercises have been the traditional means of strengthening the quadriceps. The clinical use of CKC exercises has significantly increased during the past several years as they simulate and replicate many functional movements (10). The use of unilateral weight bearing exercises in the rehabilitation of the knee dysfunction is supported by extensive analysis of EMG signal amplitude of thigh muscle. Use of lateral step up, maximal one legged squat and forward step up exercises for improving or targeting quadriceps activation in rehabilitation (24). In recent years importance of using closed chain evaluation and rehabilitation has been stressed due to the belief that closed as opposed to open kinetic chain movement is more closely related to function (25).

Topical heat and cold are commonly used to treat injuries of musculoskeletal system (bones, ligaments, muscles, tendons). These modalities are useful adjuncts to exercise medication and education for the comprehensive treatment of many musculoskeletal conditions (26). There is a popular opinion that CKC exercises tend to promote function more than do OKC exercises because CKC exercises involve primarily weight bearing activities. During the swing phase, the quadriceps femoris muscle may be required to produce a large amount of OKC hip flexion and extension torque to maximize the stride length. This functional activity includes both OKC and CKC knee extension may actually do more to improve function in this circumstance that simply using one type of exercise (27).

Conclusion

Results of this study show that the closed kinetic chain exercise along with the hot pack are more effective in improving the quadriceps strength and functional status of women with osteoarthritic knees. Improvement in quadriceps strength was more marked in group B and contributes to functional status outcome.

The values of quadriceps strength between and within the group were significant and the values of WOMAC between the groups were not significant but within the group the values were significant.

The study therefore concludes that null hypothesis that CKC exercises along with hot pack are no more effective in improving quadriceps strength and functional status of women with osteoarthritic knees is rejected and the experimental hypothesis that CKC exercises are effective in improving quadriceps strength and functional status of women with osteoarthritic knees.

Limitations of the study. Time period for the study was only 5 weeks and the frequency was only 3 times per week. Keeping in mind the time considerations, increase in muscle girth would not have been possible and hence that was not included under dependent variable. The therapeutic OKC and CKC protocol used for the patient was little hectic for the osteoarthritic elderly patient and patient might felt discomfort. Small sample size (i.e. number of subjects included were less, only 30 patients were included). Only female subjects were chosen for the study.

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