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Original Research Article

EFFECTIVENESS OF OPEN KINEMATIC CHAIN EXERCISES VERSUS CLOSED KINEMATIC CHAIN EXERCISES OF KNEE IN MENISCAL INSTABILITY ATHLETES

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ABSTRACT

Background and Purpose: The most common form of meniscal injury is mechanical failure of the tissue due to degeneration or trauma resulting in a tear.In a recent study by Shaji et al (2013) states that OKC and CKC are used often in clinical settings to treat patient's lower extremity injuries. No study is there on effect of OKC and CKC on strength and stability of knee in meniscal instability.

Materials and Methods: Thirty athletes were randomly selected into two groups of fifteen each based on inclusion and exclusion criteria and were given OKC exercises in one group, CKC exercises in another for one month. Pre-treatment and post-treatment values of hamstrings and quadriceps muscle strength and knee function score were measured and analysed statistically.

Results: Results showed that P value is < 0.0001 for strength in hamstrings (OKC) extremely significant and P value is 0.0080 for quadriceps (OKC) very significant and P value is 0.0004 for stability in both groups is extremely significant.

Conclusion: OKC and CKC exercises both were effective in improving knee strength and stability, but in OKC strength improvement is better than CKC and in CKC stability is better improved.

KEYWORDS: OKC, CKC, Knee Strength, Lysholm knee scoring system, Meniscal instability.

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INTRODUCTION

The menisci are a pair of semi-lunar fibro-cartilaginous structures found between the femoral condyles and tibial plateau in the knee joint. The medial and lateral menisci are each approximately 3cm wide [1]. The medial meniscus is approximately 4 to 5cm in length. The lateral meniscus is approximately 3 to 4cm in length. The normal meniscus is composed of approximately 70% of water & 30% of organic matter. The organic matter made up of approximately 75% of Collagen(type I, II,III,IV,V,VI & XVIII) & 25% of other organic matter including Proteoglycons(15%), DNA(2%), Adhesion Proteoglycons (<1%) & Elastin (<1%).

Arnoczky & Warren, et al [2] first described the blood supply of each meniscus. They illustrated a micro vascular peri-meniscal plexus supplied by the vascularised synovial tissue on the periphery of the menisci. These plexus is formed

from the medial and lateral geniculate arteries, which are branches of popliteal artery. The menisci serve several important functions. They facilitate load transmission across the tibiofemoral joint by improving the congruency of the articulating surfaces and increase the area of joint contact [3]. Medial menisci transmits 50% of load on medial compartment. Lateral menisci transmit 70% of load on lateral compartment. They act as important shock absorber by virtue of their visco-elastic properties. They assist in joint lubrication and articular cartilage nutrition by maintaining a synovial fluid film over the articular surfaces & compressing the synovial fluid into the articular cartilage. They promote proprioception when proprioceptive fibers within the meniscus are stimulated by meniscal motion. In 1948, Fairbank [4] examined post menisectomy knees and noticed that over time they developed joint space narrowing & femoral condylar flattening. He is first to describe the load bearing function of the meniscus. When an axial load is applied across the knee joint the menisci experience tensile, compressive & shear stresses [5].

It is known that degeneration renders the menisci more prone to injury [6]. Osteoarthritis leads to degenerative changes in the menisci as well as the surrounding cartilage, and has been implicated in ~75% of all meniscal tears and extrusions [7,8]. Osteoarthritis affects the geometry of menisci, causing thickening of the medial posterior and lateral anterior horns. This in turn can affect the biomechanics of the tissue leading to injury [9]. Adams et al. (1983) assessed the glycosaminoglycan (GAG) content of menisci in a beagle model of osteoarthritis [10]. One week after induction of osteoarthritis the water content increased as the GAG content decreased. After 15 months the water content had returned to normal and the GAG content had reached elevated levels, suggesting stiffening of the tissue. Radial displacement/extrusion of the meniscus as a result of osteoarthritis leads to joint space narrowing [11].

The most common form of meniscal injury is mechanical failure of the tissue due to degeneration or trauma resulting in a tear. Meniscal tears can be categorized into the following types: longitudinal, horizontal, radial, oblique, and complex [12-15]. Longitudinal tears occur in a vertical direction and can vary in length from ~1 mm to the length of the meniscus. Horizontal tears develop due to shear stresses generated by inferior and superior sections of the meniscus and are more common in elderly patients. Radial tears begin at the inner edge; however, radial tears extend radially toward the periphery and disrupt the meniscus' ability to contain hoop stresses. Oblique tears are similar to radial tears in that they also start at the inner edge of the meniscus, however, these tears slant inwards, and along with longitudinal tears have been shown to make up 81% of all tears. Complex tears are composed of several different tears, associated with degeneration and their incidence has been shown to increase with age. Meniscal tears can reveal themselves through various symptoms. Common symptoms include pain, a catching sensation, "giving way" and effusion [16]. The incidence of meniscal tears has been shown to be approximately 60 to 70 per 100,000 with 70 to 80% of tears occurring in males [17].

Campbell et al. (2001) showed that tears occurred almost twice as often in the medial meniscus compared with the lateral meniscus, with 66% and 34%, respectively [18]. The normal function of the meniscus is reliant on the ligaments of the knee and there is an increase in meniscal injury with ACL deficiency [19-20]. A treatment option varies by age of the patient and extent of the torn meniscus. It includes physiotherapy, NSAIDS for minimally symptomatic tears. Surgery for the symptomatic tears that causing abnormalities of joint motion, catching and locking in that ROM.

Physiotherapy treatment includes to decrease pain and disability [21], to increase Stability [22], Mobilization [23], Bracing [24], CPM [25], Progressive Weight Bearing Exercises [26,27], Accelerated Rehabilitation [28], Knee strengthening [29], Home Based Exercise Programme [30], NMES [31-34].

In literature many authors conducted studies on meniscal injuries, likewise Moffet et al (1994) [35] conducted a randomized controlled trial on the efficacy of an early, intensive, supervised rehabilitation program on knee strength recovery in the first 3 weeks post meniscectomy. Strength

measurements were performed preoperatively and 3 weeks post surgery at 30°/s and 180°/s on an isokinetic dynamometer. They demonstrated that patients who received 9 supervised physical therapy visits had better knee extensor strength recovery than patients who only received a home based program

In a recent study by Shaji John Kachanathu [36], states that an Open Kinematics Chain (OKC) is performed when the limb is not fixed and allowed to move freely through space. It helps in decreasing the joint compression. Closed Kinematics Chain (CKC) is performed when the limb is fixed or maintains contact with a ground reactive force. It helps in decreasing joint translation and increased functionality [37]. OKC and CKC are used often in clinical settings to treat patient's lower extremity injuries. This study is intended to find out effectiveness of OKC and CKC exercise training in the management of meniscal injuries.

There are no studies on OKC and CKC exercises on meniscal instability in particular. The present study is to know the effectiveness of OKC and CKC exercises in meniscal instability athletes.

MATERIALS AND METHODS

Prior to the commencement of the procedure, informed written consent was taken from the participants. Only those willing to take treatment intervention for 30min daily five times a week for one month one session per day were recruited for the study. The Thirty (30) subjects were randomly allocated to two groups of fifteen (15) each by simple random sampling. All the participants were screened for inclusion and exclusion criteria and then they were requested to participate in the study. Those willing to participate in the study were given a brief idea about the nature of the study and the intervention. The demographic data including age, side of affection and duration of symptom were collected through data collection sheet. Initial evaluation of Strength of Hamstrings and Quadriceps was done using Manual Muscle Testing [38]. Knee function was measured by Lysholm knee Scoring System [39] as an interventional outcome measures. Both groups were treated 30min daily each session, five times a week for one month and one session per day.

PROCEDURE:

Group A: Open Kinetic Chain

Sitting Knee extension: Sitting in a chair, with back resting against the back of the chair. Feet are flat on the floor place a rolled-up towel under knees to lift them up.

Extend leg in front of, parallel to the floor, until knee is straight.

Lower the leg back to the starting position, so that the ball of foot rests on the floor again.

Prone Knee bending: Prone lying with bending leg towards back.

Hamstring Curls: Standing, holding onto a solid object for balance. Have the patient pick up the foot and flex the knee. Maximum resistance from gravity occurs when the knee is at 90^0 flexion. Add resistance with ankle weights or a weighted boot. If the patient flexes the hip, stabilize it by having the patient place the anterior thigh against a wall or solid object.

Chair scoots: Sitting in a chair, with the involved knee flexed to the end of its available range and the foot firmly planted on the floor. Have the patient move forward in the chair, not allowing the foot to slide, and then hold the position for a comfortable, sustained stretch of the knee extensors.

Group B: Closed Kinetic Chain

Wall Slides: Stand with back against a wall, feet shoulder-width apart, 1½ to 2 feet away from wall. Slowly slide down wall, so that knees will bend. Do not let knees go past toes while bending. Slide back up the wall to the starting position. Keep the back against wall during entire exercise.

Half squats: Wide stance feet wider than shoulder width, toes pointing forward; arms raised to chest height, palms facing. Keep body upright; bend knees and hips to lower body, knees should not go in front of toes. Return to Starting Position.

Lunges: Stand erect with feet about one shoulder width apart. Put hands on hips, keep the back as straight as possible, Lunges should be performed on solid, and even ground, not on an exercise mat. Take a large step forward with one leg. As the step forwards, lower the hips and bend the knees until they both form 90°

angles. Front knee should not extend over toes and back knee should not touch the ground. Return to starting position.

Stationary Bicycle: Height adjusted for seating which will be appropriate for moving both knees in coordination with the pedals of the cycle for knee flexion and extension.

Resistance of pedals was adjusted for ease in knee flexion and extension depending on their strength levels. Cycling can be done by number of revolutions per min or for a period of total 5 min.

Pre and Post treatment values of outcome parameters were collected and analyzed statistically using student t test and ANOVA.

RESULTS

Results showed that P value is < 0.0001 for strength in hamstrings (OKC Vs CKC) extremely significant and P value is 0.0080 for quadriceps (OKC Vs CKC) very significant and P value is 0.0004 for stability (OKC Vs CKC) in both groups is extremely significant.

Table 1: Showing the difference between MMT, OKC Vs CKC Knee flexors post treatment values.

	Open Kinetic Chain	Closed Kinetic Chain
MEAN	4.233	3.819
# Of Points	15	15
Std Deviation	0.2582	0.1756
Std error	0.06667	0.04533
P value	<0.0001	

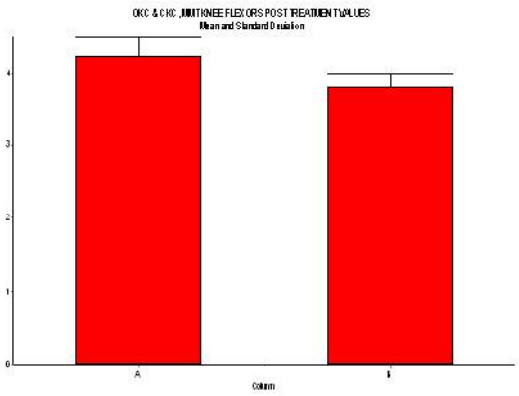


Table 2: Showing the difference between MMT, OKC Vs CKC Knee Extensors Post Treatment values.

	Open Kinetic Chain	Closed Kinetic Chain
MEAN	4.052	3.643
# Of Points	15	15
Std Deviation	0.4338	0.346
Std error	0.112	0.08933
P value	0.008	

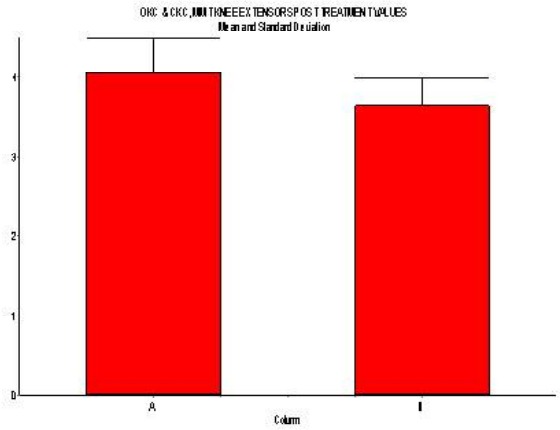
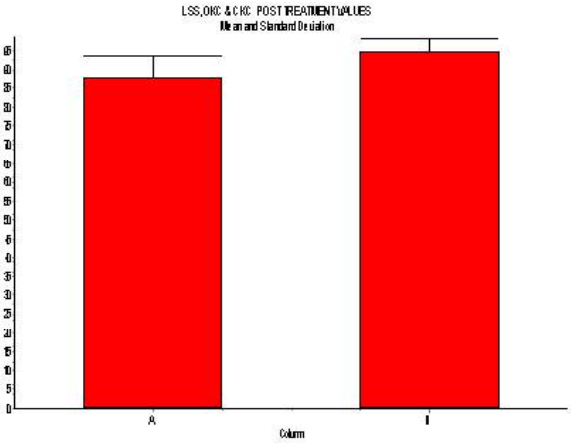


Table 3: Showing the difference between LSS, OKC Vs CKC Post Treatment values.

	Open Kinetic Chain	Closed Kinetic Chain
MEAN	87.667	94.733
# Of Points	15	15
Std Deviation	5.936	3.411
Std error	1.533	0.8808
P value	0.0004	



DISCUSSION

Open kinematic chain exercises & closed kinematic chain exercises are given for knee rehabilitation in most of the knee injuries in athletes. In this present study OKC exercises and CKC exercises were compared to know their effect on strength and stability in relation to knee over all function in meniscal instability athletes which showed increase strength in OKC group with P value <0.0001 and increase stability and overall function in CKC group with and P value 0.0004 which is extremely significant for both groups.

In this study both OKC and CKC group showed marked increase in strength of Hamstrings and Quadriceps with P value <0.0001 which is extremely significant after treatment period, but more improvement is seen in OKC group. Both

OKC and CKC exercises are effective in the improvement of strength and balance; however controversies exist regarding the onset of open kinetic chain (OKC) exercises.

A study by Escamilla et al [40], said that quadriceps muscle activity was greatest in CKCE when the knee was near full flexion and in OKCE when the knee was near full extension and patella-femoral compressive forces were greatest in CKCE near full flexion and in the mid-range of the knee extending phase in OKCE similarly in another study by Ninos JC et al [41], suggested about disadvantage with CKC exercises is that, due to their complex character, they may not isolate separate muscles sufficiently to achieve optimal increases in muscle strength. A weak quadriceps musculature will possibly not receive enough stimuli to regain maximal strength. Even in this study also improvement in OKC group strength gains are better than CKC group may be because significant changes in muscle activity did occur with changes in knee flexion angles in the vastus medialis and vastus lateralis but not in the semi membranosus or semitendinosus or biceps femoris. In contrast, exercises that involve isolated hamstring contraction do not strain the knee ligaments at any knee position or magnitude of the muscle contraction [42] which supports the present study about quadriceps strength improvement in CKC group is less than OKC group.

Both OKC and CKC group showed improvement in stability of knee with P value =0.0004 which is extremely significant after treatment period, but more improvement is seen in CKC group.

A study by Witvrouw et al [43], concluded that both OKC and CKC showed significant decrease in pain and an increase in functional performance and similarly DeCarlo et al [44], says both OKC and CKC can be used for improving function and stability of knee. A study by Beynnon BD, et al[45], Bynum EB et al (1995) [46], Henriksson M et al (2002) [47] Shelbourne KD et al (1990) [48], CKC exercises have been frequently used and recommended for rehabilitation after knee ligament injury because they were considered to be safer than exercises in OKC. In another study by S. van Grinsven et al [49], revealed that an accelerated protocol without postoperative bracing, in which reduction of pain, swelling and inflammation, regaining range of motion (ROM), strength and neuromuscular control are the most important aims, has important advantages and does not lead to stability problems.

In a study by Kvist J et al [50] said that closed kinetic chain exercises are preferable to open kinetic chain exercises, and importance should be attached to the spontaneous co-activation of the quadriceps and gastronemius muscles which supports the improvements in CKC function and stability of knee is more than OKC group in this current study because Co-activation of the quadriceps and gastronemius muscles seems to be important for knee stability which is more in CKC, whereas hamstring muscle co-activation was insignificant which is more in OKC.

CONCLUSION

In this study 30 subjects with meniscal instability were selected randomly based on inclusion and exclusion criteria and divided into two groups Group A (15 Subjects) OKC exercises and Group B (15 Subjects) CKC exercises were given for one month duration.

Pre and Post treatment values of Hamstring and quadriceps strength and knee function values were statistically analyzed after the said treatment duration.

Results showed that OKC exercises are better than CKC exercises in improving strength where as CKC exercises were proved better than OKC exercises in improving Knee function.

ABBREVIATIONS

MMT - Manual Muscle Test
OKC - Open Kinetic Chain
CKC - Closed Kinetic Chain
CPM - Continuous Passive Movements
NMES - Neuromuscular Electrical Stimulation
ROM - Range of Motion

Conflicts of interest: **None**

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