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Effect of SLR and Isometric Exercise on Quadriceps Lag of Normal Health Individual

Anirban Patra[1], Niraj Kumar[2], Archana Chauhan[3]

Abstract

Introduction: The term "muscle lag" and the more specific term "extensor lag" and "quadriceps lag" have been in use for at least 40 years. Muscle an inability to actively move a joint to its passive limit [5]. Extensor lag accompanying knee lesions is a function of great loss in mechanical advantage of the quadriceps during the last 15 degrees of the extensor range, 60 percent increase inforce being needed to complete the extension [3]. Straight leg raising for increasing quadriceps strength was unable to isolate the vastus medialis from the vastus lateralis muscle [8, 10,12]. *Aim and Objective:* The objective of this study is to determine the effect of SLR and isometric quadriceps exercise on quadriceps lag of normal health individual. *Need of Study:* To best of our knowledge no studies have been done on to determine the effect of SLR and isometric quadriceps exercise on quadriceps lag of normal health individual. *Methodology:* A Total of 60 normal healthy young subjects were recruited for the study. The subjects were divided into two groups. Group A and Group B. Group A 30 subjects were included with their mean age (24.76+3.38) year. Group B 30 subjects were included with their mean age (27.16+3.94) year. A subject was given isometric exercise and Group B subjects were given SLR for 3 weeks. *Results:* Independent t-test was used between the group A and B before and after exercise. It showed that there was no significant difference between the group A and B before exercise. But there was significant difference between the group A and B after exercise ($P < 0.05$). *Future Research:* The present study was done on small sample size. So, future research on large sample population can be done & Present study duration was 3 weeks, so a study of long duration can be done. *Limitation of the Study:* 1. Since the study was conducted with healthy subject the results can not be readily generalized to a patient population without further research. 2. Since the instrumentation used is a universal protractor goniometer (360^{o}) there are some probabilities of errors in the reading as compared to the method incorporating video imaging technique. 3. The sample size is small. *Conclusion:* The study has shown that the quadriceps lag can be greater reduce on isometric exercise compare to SLR exercise. So, the study concluded that the Isometric exercise have more effect on quadriceps lag compare to SLR exercise.

Kyewords: Universal Goniometer; Isometric Exercise & Slr Exercise.

Introduction

The term "muscle lag" and the more specific term " extensor lag" and "quadriceps lag" have been in use for at least 40 years. Muscle an inability to actively move a joint to its passive limit [5].

The main factors may precipitate pathological muscle lag – (1) an abnormal increase in muscle length (as may occur following suture of rupture muscle, or fracture with loss of bone length). (2) Disuse atrophy (3) Myopathy (4) Neurological (5) Pain induced or other arthrogenic muscle inhibition [5].

Force developed by a contracting quadriceps must be increased 60% to achieve the final 15 degrees of active knee extension. Quadriceps weakness will be most evident in this final extension range, and is often accompanied by lag [5,6].

Fredrick J Lieb, et al., found out assign responsibility for the last 15 of knee extension to the vastus medialis. Its action is deemed essential for maximum joint stability [3, 4].

Duchenne described the extensor of the knee as the rectus femoris, vastus lateralis, and vastus medialis and noted vastus medialis has somewhat greater power of extension than does the vastus leteralis. Smillee stated that the " vastus medialis is by far the most important component of the

Author Affiliation: [1,3]Assistant Professor [2]Associate Professor, Dept. of Physiotherapy, Shri Guru Ram Rai Institute of Medical & Health Sciences, Patel Nagar Dehradun, Uttarakhand 248001, India.

Corresponding Author: Niraj Kumar, Associate Professor, Dept. of Physiotherapy, Shri Guru Ram Rai Institute of Medical & Health Sciences, Patel Nagar Dehradun, Uttarakhand 248001, India.

E-mail: drnirajkumar25@gmail.com

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extensor apparatus, for not only are these final few degrees of extension the most vital in the whole range, but it is the vastus medialis which is most entirely responsible for the stabilization and protection of the joint from injury [3].

The extensor lag accompanying knee lesions is a function of great loss in mechanical advantage of the quadriceps during the last 15 degrees of the extensor range, 60 percent increase inforce being needed to complete the extension [3].

Knight et al., compared straight leg raising with knee extension and actually found the vastus laterailis muscle more active [10].

Straight leg raising for increasing quadriceps strength was unable to isolate the vastus medialis from the vastus lateralis muscle [8,10,12].

Aim and Objective

The objective of this study is to determine the effect of SLR and isometric quadriceps exercise on quadriceps lag of normal health individual.

Statement of Question

What is the effect of SLR and isometric exercise on quadriceps lag of normal healthy individual?

Hypothesis

On isometric exercise, quadriceps lag will more reduce compare to SLR exercise.

Operational Definition

Extensor lag – This refers to the inability to fully extend the knee actively, although passively full extension is possible. This results from lengthening of the extensor mechanism or weakening of the quadriceps. With an extensor lag, the patient cannot actively extend to a completely straight position (angle of 0 measured between the femur and tibia). Passive extension is not limited however [16,13,17].

Review of Literature

Knee Joint

It is compound synovial joint, incorporating two condyles joints between the condyles of the femur and tibia, joint between the femur and patella [14].

Articular surfaces

The bone involved are the femur, tibia, and patella. The articular surfaces are the large curved condyles of the femur, the flattened condyles of the tibia, and the facets of the patella [1,2].

Movements of the knee joint

When the leg is fully extended, the knee 'locks' owing to medial rotation of the femur on the tibia. This makes the lower limb a solid column and more adapted from weight bearing. To 'unlock' the knee the popliteus muscle contracts, there by rotating the femur laterally so that flexion at the knee can occur [1,2,27].

Joint capsule

The integrity of the joint is maintained by a vast capsular envelope reinforced judiciously by retinaculam, tendons and ligaments [1,2].

To the femur the capsule remains attached Posteriorly around the articular margins at the condyles and above the intercondylar notch. On the lateral condyle this continuity is breached by the popliteus tendon unit panes over the back of the tibia,. Here the capsule forms a free reflection downward and laterally to the head of the fibula on the arcuate ligament. Medially, the capsule is greatly thickened forming the deep capsular ligaments deep to the medial ligament of the knee joint, it forms a thickening of the capsule extending from the medial epicondyle of the femur to the medial meniscus which it holds firmly to the femur [2].

Ligaments

Patellar ligament: This very strong, thick band is the continuation of the tendon at the quadriceps femoris muscle. The patellar ligament is continuous with the fibrous capsule at the knee joint and is most easily felt when the leg is extended. The superior part of its deep surface is separated from the synovial membrane of the knee joint by a mass of loose fatty tissue called the infrapatellar fat pad. The inferior part of the patellar ligament is separated from the anterior surface of the tibia by the deep infrapatellar bursesa [1,2].

Fibular collateral ligament: The fibular collateral ligament (lateral ligament) extends inferiorly from the lateral epicondyle of the femur to the lateral surface at the head of the fibula. The tendon of the poplitens muscle passes deep to the fibular collateral ligament, separating it from the lateral meniscus. The fibular collateral ligament is fused with the fibrous capsule at the knee joint superiorly [1,2].

Tibial collateral ligament

The ligament (also known as the medial ligament) which extends from the medial epicondyle at the femur to the medial condyle and superior part of the medial surface of the tibia. It is a thickening at the fibrous capsule at the knee joint and is partly continuous with the tendon at the adductor magnus muscle. T he inferior end of the ligament is separated from the tibia by the medial inferior funicular vessels and nerve. The deep fibers of the tibial collateral ligament are firmly attached to the medial meniscus and the fibrous capsule of the knee joint [1,2,4,5].

Oblique popliteal ligament

This broad band is an expansion at the tendon ot the semimembranosus muscle. The oblique poplital ligament strengthens the fibrous capsule at the tibia and passes superolaterally to attach to the central part of the posterior aspect of the fibrous capsule of the knee joint [1,2].

Arcuate popliteal ligament

It is a V-shaped band fibers strengthens the fibrous capsule Posteriorly. The stem at the ligament arises from the posterior aspect of the head of the fibula. This ligament spreads out over the posterior surface at the knee joint.

The cruciate ligament of the knee joint

These are very strong ligaments are within the capsule of the joint but outside the synovial cavity. Joining the femur and tibia, they are located between the medial and lateral condyles and separated from the joint cavity by the synovial membrane. The cruciate ligaments are strong, rounded bands that cross each other obliquely in a manner similar to an x. they are named anterior and posterior according to their site of attachment to the tibia i.e. the anterior cruciate ligament attaches to the tibia anteriorly and the posterior cruciate ligament attaches to it Posteriorly. These ligament are essential to the antero-posterior stability of the knee joint, especially when it is flexed [1,2].

Menisci of the knee joint

The medial and lateral menisci are plates of fibrocartilage on the articular surface of the tibia. They act like shock absorbers. Because they are basically C – shaped they were formerly called semilunar cartilages [1].

Medial meniscus: This C- shaped cartilage is broader posteriorly than anteriorly. Its anterior end is attached to the anterior inter condylar area of the tibia, anterior to the attachment of the anterior cruciate ligament [1,2,45].

Lateral meniscus: This C-shaped cartilage is nearly circular and lateral meniscus is smaller and more freely movable than the medial meniscus The tendon of the popliteus muscle separates the lateral meniscus from the fibular collateral ligament [1,2].

Knee joint motions

The primary movements of the knee joint are flexion/extension and, to a lesser extent, medial-lateral rotation. The knee joint can also undergoes tibial or femoral displacement anteriorly and posteriorly, and some abduction and adduction through varus and valgus forces. However, these movements are generally not considered part of the function of the join, but are rather part of the cost at the tremendous compromise between mobility and stability, Normal knee joint motions, including both osteokinematics (degree of freedom) and arthokinematics. (intra-articular movement with in the joint) [45].

Locking and unlocking

Medial rotation of the femur that accompanies the final stages at knee extension is not voluntarily of produced by muscular forces, it is referred to as automatic or terminal rotation of the knee joint. This rotation within the joint that accompanies the end of extension also brings the knee joint into the close packed or locked position. The tibial tubercles are lodged in the interconylar notch, the mechanism or screw home mechanism of the knee. To initiate flexion, the knee must first be unlocked. That is, the medially rotated femur cannot flex in the sagittal plane, but must laterally rotate before flexion can proceed. A flexion force will automatically result in lateral rotation of the femur since the longer medial side will move before the shorter lateral side of the joint [27,45].

Active Insufficiency

Active insufficiency is the diminished ability of a muscle to produce or maintain active tension. It is most commonly encountered when the full ROM is attempted simultaneously at all joints crossed by a two-or multi joint muscle. Therefore, during active shortening a two-joint muscle will become actively insufficient at a point prior to the end of a joint range, when full ROM at all joints occurs simultaneously. Active insufficiency also may occur in one-joint muscles, but is not as common [45,46].

Biomechanics of the Knee Joint

Knee joint motion is prescribed by the interaction of several biological structures; bone, cartilage, ligaments, tendons, muscle and other soft tissues such as the retinaculum and IT bank. The articulating surfaces of the femur, patella and tibia consist of articular cartilage which in combination with synovial fluid, permit a relatively frictionless contact surface. Extreme range of motion of the tibia relative to the femur is constrained by four ligaments. The medial collateral ligament (MCL) and the lateral collateral ligament (LCL) prevent the femur from translating medially or laterally with respect to the tibia and prevent varus/valgus motion of the knee. The anterior cruciate ligament (ACL) prevents the posterior translation of the femur with respect to the tibia whereas the posterior cruciate ligament (PCL) prevents the anterior motion of the femur relative to the tibia [39,45,46,30].

The Function of the Patella in Joint Mechanics

The function of the patella in patellofemoral joint biomechanics is complex and its importance has been subject to debate. The primary function of the patella is to transmit extension forces from the femur to the tibia. The quadriceps muscle group converges on the superior end of the patella. This centralizes the muscular forces and allows the patella to function as a guide in transmitting those forces to the patella tendon [39,40,45].

Methodology

Sample

A Total number of 60 normal healthy young subjects were recruited for the study. The subjects were divided into two groups. Group A and Group B. Group A 30 subjects were included with their mean age (24.76+3.38) year. Group B 30 subjects were included with their mean age (27.16+3.94) year. The study was conducted in the physiotherapy OPD at Dolphin Institute of Bio Medical and Natural Sciences Dehradun. The subjects were selected on the basis of inclusion criteria- age – 20-35 years, Sex- Male and Female & Normal Knee ROM and exclusion criteria individuals with lower limb lesions or injuries that affects active and passive range of motion at knee joint., With any musculoskeletal disorder, Any underlying knee pathology, Knee surgery, Knee joint pain, Knee deformity, Knee injury, Peripheral neurological deficits, Fracture, Inflammatory joint disease, O.A., Limb length discrepancy, R.A., Diabetic neuropathy, Muscle atrophy Normal healthy individuals. Instrumentation for data collection includes Universal goniometer.

Protocol

Prior to the participation all the subjects were informed about the study and a consent form was signed.

The subjects were asked to sit comfortably on a quadriceps table with the trunk flexed to 45^o hamstrings relaxed.

They were asked to perform maximum voluntary active extension of the knee and the angle of the knee extension.

Three readings were taken and reading had taken as close as in between three reading. Then examiner passively extends the subjects knee and with the help of an assistant, the angle of the knee extension. Three readings were taken for this too. The reading had taken as close as in between three reading. The difference between passive limit of extension and active limit at extension is the physiological quadriceps lag. After measuring the quadriceps lag group A subjects were given isometric exercise and Group B subjects were given SLR for 3 weeks.

Procedure

The participants were 60 normal healthy young adults. The procedure starts by asked to sit comfortably on a quadriceps table with the trunk flexed to 45^o hamstrings relaxed. supported in approximately 45^o flexion to minimize any resistance from hamstring muscle lightness during the tests. So that the knee is approximately at 90^o flexion.

Therapist stood on the side of the right leg and places the goniometer on the lateral joint line.

The fixed arm at the goniometer is positioned along the long axis of the femur and moving arm is aligned with the line between femoral head and lateral malleolus. The subject is subject is asked to actively extend the knee to the maximum and angle is measured in respect to the previous position of the leg subsequently three readings were taken.

Now the passive limit of knee extension is determined by the therapist straightening the relaxed knee with a hand be hind the heel until the subjects thigh just cleared the couch.

Subsequently three readings were taken. Between three readings which reading was as close as that was taken.

Isometric Quadriceps Exercise

With the knee slight flexed bend. Place rolled towels under the knee. Try to straighten the knee and push the towels. Tighten the thigh muscles on top of the leg as tightly as possible and hold. The knee will flatten and knee cap will move slightly upward. Hold 10 seconds and then relax (Fig. 1).

Straight Leg Raise

Lie flat on back on either a bed or on the floor. Ben on knee, placing other foot flat on the bed. (This helps to stabilize pelvis and protects lower back). Straighten the other knee. Tighten the muscle on the top of the thigh of the straight leg and slowly raise the entire leg 12 to 18 inches off the bed. Slowly lower the leg and relax. Repeat this exercise 10 times, and then progress to doing 3 sets of 10 repetitions with 1 to 2 minute rest between sets. This exercise is isometric at the knee, but not at the hip (Fig. 2).

Data Analysis: Data analysis was done using SPSS-12.0 version. Independent t-test was used to calculated mean and standard deviation for age, weight and height, AKE, PKE, QL, QLA 21 days.

Paired t-test was used to compare the QL, (Quadriceps lag) QLA 21 days (Quadriceps lag after 21 days exercise) with in group A and group B. Independent t-test was used between the groups. Significant level was set at $p<0.05$.

Fig. 1: Isometric Quadriceps Exercise

Fig. 1: Straight Leg Raising (SLR)

Results

Mean and standard deviation of age, weight and height was calculated for all subjects of group A and group B showed significant in age ($p < 0.05$) in significant weight and height ($p > 0.05$) (Table 1 & Fig. 3).

Mean and standard deviation of AKE, PKE, QL, QL, AL 21 days of exercise was calculated for the all subjects of group A and B (Table 2 & Fig. 4).

Paired t-test was done with in the group to compare the QLA within the group. That is before and after 21 day exercise shows significant change in QLA ($P < 0.05$) (Table 3 & Fig. 5).

Independent t-test was used between the group A and B before and after exercise. It showed that there was no significant difference between the group A and B before exercise. But there was significant difference between the group A and B after exercise ($P < 0.05$).

Group A – isometric Exercise

Group B – Straight Leg Raise

Table 1: Mean and Standard deviation of Age, Weight and Height for the subjects of Group A and Group B

Variable	Age Mean ± SD	Weight Mean ± SD	Height Mean ± SD
Group A	24.76±3.38	56.73±5.84	161.53±9.78
Group B	27.16±3.94	59.23±4.95	158.46±12.19
T-value	-2.59	-1.787	1.074
P-value	0.014	0.079	0.287

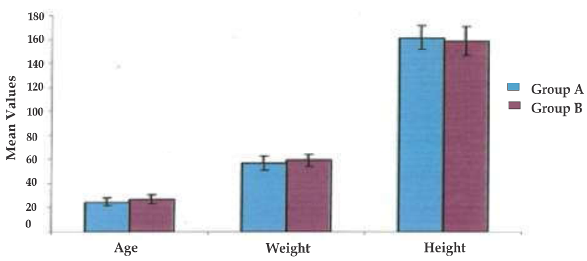

Fig. 3: Comparison of mean values of Age. Weight and Height for subjects of Group A and B

Table 2: Mean and Standard deviation of Active knee extension (AKE_), Passive Knee Extension (PKE), Quadricep lag (QL) and Quadricep lag after 21 days of treatment (QLA21) for the subjects of Group A and Group B

Group	AKE Mean ± SD	PKE Mean ± SD	QL Mean ± SD	AKE Mean ± SD	PKE Mean ± SD	QLA21 Mean ± SD	t-value	p-value
Group A	1.46 ± 0.49	3.78 ± 0.69	2.32 ± 0.57	1.76 ± 0.39	3.91 ± 0.67	1.42 ± 0.45	13.54	.00122
Group B	1.56 ± 0.37	3.65 ± 0.69	2.13 ± 0.74	3.45 ± 0.45	3.56 ± 0.52	1.75 ± 0.61	7.62	.0058

Table 3: Comparison of mean value for quadriceps lag and after 21 days (QLA21) for subjects between Group A and Group B

Variable	QLA Mean ± SD	QLA21 Mean ± SD
Group A	2.23±.576	1.42±.459
Group B	2.13±.741	1.75±.619
T-value	1.089	2.343
P-value	0.281	0.023

AKE = Active knee extension

PKE = Passive knee extension

QLA = Quadriceps lag

QLA21 = Quadriceps lag after 21 days exercise

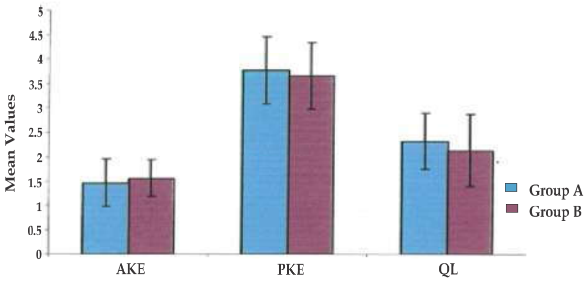

Fig. 4: Comparison of mean values of Active Knee Extension (AKE), Passive Knee Extension (PKE) and Quadricep Lag for Subjects of Group A and B

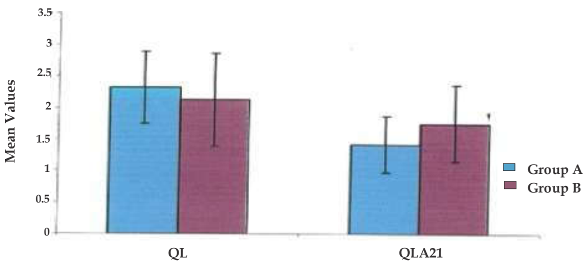

Fig. 5: Comparison of mean values of Quadricep Lag (QL) and Quadricep Lag after 21 days (QLA21) for Subjects of Group A and B

Discussion

The objective of the study was to determine the effect of SLR and isometric quadriceps exercise on quadriceps lag at normal healthy individual.

It was hypothesized that isometric exercise will reduce the affectively quadriceps lag compare to SLR exercise.

Edwards Grood et al. has shown that very large quadriceps forces are required to accomplish the last 15° of extension during leg raising exercises, typically twice those required to reach 30° of flexion. The large forces that are required to obtain full extension explain why an extensor lag occurs with quadriceps weakness even though a full passive range of motion in possible [21].

Krebs DE et al. results showed that motor unit activity depends not only upon joint angle, but also upon peripheral receptor feedback, which is altered in the post arthrotomy limits, producing the characteristic 'extensor lag' or inability to maintain the knee at 0 degree while flexing the hip [22].

Rafael F et al. suggests that SLR may be more effective in developing the rectus femoris while isometric may be more effective in developing the vasti muscles. Vasti muscles (VM) are the main muscle of knee extension. So the isometric is more effective compare to SLR [23].

Contraction is termed isometric (iso-constant, metric length), as no change takes place in the distance between the muscle's points of attachment (Rodgers and Cavanagh 1984) [46].

Although no motion is accomplished and no mechanical work is performed during an isometric contraction (Komi, 1986), muscle work (physiologic work) is performed energy is expended and is mostly dissipated on heat. This type of muscle work is called static work. The tension in a muscle varies with the type of contraction [46].

Isometric contractions produce greater tension than do concentric contractions. The longer contraction time of the isometric contractions allows greater cross-bridge formation by the contractile components, thus permitting greater tension to be generated (Kroll, 1987) [26,46].

Isometric quadriceps exercises in full knee extension may be effective in preventing or resolving a knee extensor lag, and most articular lesions will not be engaged with the knee in full extension [28,43].

Gregory M Karst et al. found in order to reduce the risk of exacerbating patellofemoral joint irritation, isometric QF exercises performed with the knee in full extension, such as the QS and SLR exercise used to reduce quadriceps lag, isometric quadriceps exercised is more effective to reduce lag. They also suggest in cases requiring QF strengthening in the fully extended knee position, isometric QS may be the treatment of choice on quadriceps lag [47].

Future Research

1. The present study was done on small sample size. So, future research on large sample population can be done.
2. Present study duration was 3 weeks, so a study of long duration can be done.
3. Present study can be done with other different knee joint exercise

Relevance to Clinical Practice

Extensor lag can disturb the knee stability. If lag is more it disturb the normal gait pattern and functional activities. Extensor lag is more means knee stability is less. It is very prone to knee injury on sports persons. Extensor lag can bring problems in case of sports persons.

Limitation of the Study

1. Since the study was conducted with healthy subject the results can not be readily generalized to a patient population without further research.
2. Since the instrumentation used is a universal protractor goniometer (360°) there are some probabilities of errors in the reading as compared to the method incorporating video imaging technique.
3. The sample size is small.

Conclusion

The study has shown that the quadriceps lag can be greater reduce on isometric exercise compare to SLR exercise. So, the study concluded that the Isometric exercise have more effect on quadriceps lag compare to SLR exercise.

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