

## Mini Review

# Is the Mini-Squat a Fundamental Knee Rehabilitative Exercise?

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The understanding of kinesiology of the knee is essential for successful rehabilitation post an injury and/or surgery. Kinesiology of both the tibiofemoral and patellofemoral joints must be considered before prescribing rehabilitative exercises to an injured knee. The mini-squat is a popular rehabilitative exercise to stabilize and strength the injured knee. The purpose of this paper is to provide a framework of evidence when one considers selecting the mini-squat as a rehabilitative exercise for the injured knee.

**Keywords:** Mini-squat; Knee; Rehabilitation

## Introduction

Mini-Squat (MS), also known, as a partial squat is a Common Closed Kinetic Chain Exercise (CKCE) often prescribed in knee rehabilitative programmes [1-3]. A popular question asked by rehabilitative science students and patients is, why MS is a preferred rehabilitative exercise to Seated Knee Extension Exercises (SKEE). Most patients with knee injuries generally have patellofemoral pain syndrome, sprained Anterior Cruciate Ligament (ACL) and/or Sprained Medial Lateral Collateral (SMCL) receive conservative therapeutic rehabilitation. Conservative rehabilitative practises prescribe MS instead of SKEE. There is controversy regarding the efficacy of MS as to SKEE during knee rehabilitation. Keys' et al. reported that MS produces more anterior tibial translation compared to SKEE, which increases the risk of further ACL and MCL injury [1]. Boling et al. and McGuinty et al. report that MS produces an anterior femoral condyle roll accompanied by posterior tibial translation, which negates the risk of ACL and MCL injury [2,3]. This short review highlights the main biomechanical and kinesiological differences between MS and SKEE.

### Biomechanical analyses of the mini-squat versus the seated knee extension exercise

Prentice et al. and Grodski and Marks reported that MS and SKEE both promote, (i) activation and co-activation of the quadriceps femoris and hamstrings reciprocally, (ii) enhances muscle strength and endurance of the quadriceps femoris and hamstrings force couple, and (iii) enhance neuromuscular facilitation between these muscles [4,5]. However the MS increases quadriceps femoris activation without increasing shear stress on a reconstructed, laxed and/or sprained ACL and induces a stronger hamstring contraction than the SKEE, which enhances knee stability [3,5]. These biomechanical differences fundamentally separate the MS from the SKEE.

Palmitier et al. [6] proposed that the shear and compressive forces around the knee joint are greatly amplified depending on the rehabilitative exercises is performed [5]. In open kinetic chain exercise (SKEE) the flexion moment increases as the knee extends from 90° flexion to full extension (0°), increasing the tension in quadriceps

femoris and patellar tendon because of its concentric muscle contraction [2]. Simultaneously, as the knee undergoes extensive, the patellofemoral contact area decreases, precipitating increased contact stress per unit that produce knee pain among patients suffering from patellofemoral pain syndrome and knee extensor mechanism injuries [3,7]. These series of event explains how the patellofemoral joint reaction forces increase during SKEE [8]. However, in CKCE (MS), the flexion moment increases during knee flexion because of concentric hamstring contraction. The eccentric lengthening of the quadriceps femoris and patellar tendon augment patellofemoral joint reaction forces. The cardinal difference between MS and SKEE is the surface contact area. In MS the patella has a much larger surface contact area with femur condyles and intercondylar groove thereby reducing the contact stress, eliminating pain knee among patients suffering patellofemoral pain syndrome [4].

### The kinesiological difference between a mini-squatting versus seated knee extension exercise

Mini squatting from 90-40° of knee extension is an application of Rule 1 of arthokinematic, which states when a convex surface articulates with a stationary concave surface, the roll and slide is in the opposite direction [9]. The application of this rule becomes important when the patient extends his/her knee from 90-40°. During the knee extension the patient's the femoral condyles (convex surface) articulates onto a fixed tibial plateau (concave surface) precipitating an anterior femoral roll and an accompanying posterior slide. These kinesiological events places the femur anteriorly translated to the fixed tibia, which places the PCL under stress and not the ACL [2,3,9]. Therefore MS serves to strengthen musculature around the knee, which stabilizes an ACL and MCL sprained knee. During the MS knee flexion from 40-90° the femoral condyles roll posteriorly, accompanied by an anterior slide. This limited range of motion between the femur on the tibia is primarily controlled by the concentric contraction of the hamstrings. During this range of motion, minimal shear force is applied to the ACL. During this joint movement the antagonist (quadriceps femoris) muscle serves the primary restraint to the concentric contraction of the hamstrings. The ACL is only under severe stress of re-injury when the tibia anteriorly hyperextends beyond the femur or when

the femur posteriorly hyperextends beyond the tibia. Mini-squatting between 40-90° ensures that the tibia is never hyperextended beyond the femur anteriorly nor that femur is posteriorly hyperextended behind the tibia to predispose the ACL to re-injury [4,10]. Any risk of an ACL re-injury will only become apparent when the tibiofemoral joint creates an angle closer to 0° of tibiofemoral extension or when the knee is flexed beyond 100° [4,9,10]. The kinesiological analysis of the common SKEE is an application of Rule 2 of arthokinematic. Rule 2 states that when a concave surface articulates with a stationary convex surface, the roll and slide occurs in the same direction [9]. The functional translation of Rule 2 suggests that during SKEE the tibia moves on the fixed femur, thereby translating the proximal tibia anterior to the distal femoral intercondylar groove. It is also important to note that combined anterior roll and slide vectors results in a larger anterior resultant vector, displacing the tibia further anteriorly, which places greater stress on the ACL [3]. Therefore the application of SKEE could compromise the strength of a weakened ACL and/or MCL. The return movement of SKEE from extension to flexion will precipitate posterior roll and slide of the tibia on the fixed femur. However the re-injury would have been incurred during the extension phase of SKEE before the tibiofemoral returns to a flexed position.

### The weeping willow mechanism of lubrication of the knee joint

A minor amount of synovial fluid is found within the articular cartilage of the tibia and femur, which provides a slippery weight bearing film that reduces friction between the epiphysis of the bones as they slide and/or roll across each other [10]. This synovial fluid is forced from the articular cartilage when the joint is compressed during the squat's knee extension (weight bearing) via elastohydrodynamic lubrication [11]. When the joint is relieved from the compressive pressure during squat's knee flexion, the synovial fluid seeps back into the articular cartilage, ready to be squeezed out the next time the joint is loaded. This mechanism is known the Weeping Willow Mechanism [10]. Mini-squatting uses this physiological mechanism to improve range of motion and dissipate knee in various pain knee injuries [11].

## Conclusion

The above-mentioned biomechanical and kinesiological events warrant the judicious application of the MS in most knee rehabilitative programmes. The application of SKEE can be prescribed later into the rehabilitative programme when the knee is stabilized.

## References

1. Keays SL, Sayers M, Melifront DB, Richardson C. Tibial displacement and rotation during seated knee extension and wall squatting: A comparative study of tibiofemoral kinematics between chronic unilateral anterior cruciate ligament deficient and healthy knees. *The Knee*. 2012; 20: 346-353.
2. Boling MC, Bolgia L, Mattacola CG, Hosey RG. Outcomes of a weight-bearing rehabilitation program for patients diagnosed with patellofemoral pain syndrome. *Arch. Phys. Med. Rehab*. 2006; 87: 1428-1435.
3. McGuinity G, Irrgangn JJ, Pezzullo D. Biomechanical consideration for rehabilitation of the knee. *Clinical Biomechanics*. 2000; 160-166.
4. Prentice WE. *Rehabilitative techniques for Sports Medicine and Athletic Training*. 5<sup>th</sup> edn. McGraw-Hill. 2011.
5. Grodski M, Marks R. Exercise following anterior cruciate ligament reconstructive surgery: Biomechanical considerations and efficacy of current approaches. *Res Sports Med*. 2008; 16: 75-96.
6. Palmitier R, Kai-Nan A, Scot S. Kinetic chain exercises in knee rehabilitation. *Sports Medicine*. 1991; 11: 402-413.
7. Baratta R, Solomonow M, Zhou B. Musculature co-activation: The role of the antagonist musculature in maintaining knee stability. *Am J Sports Med*. 1988; 16: 113-22.
8. Fu F, Woo S, Irrgang J. Current concepts for rehabilitation following anterior cruciate ligament reconstruction. *J Orthopaedic Sports Phys Therapy*. 1992; 15: 270-278
9. Mansfield PJ, Neumann DA. *Essentials of Kinesiology for the Physical Therapist Assistant*. Mosby Inc, USA. 2008.
10. Marieb EN. *Human Anatomy and Physiology*. 6<sup>th</sup> edn. Pearson Benjamin Cummings, USA. 2004.
11. Aseel Mohammed Ali, Yousif AE. Role of lubrication mechanisms in the synovial knee joints. *NUCEJ*. 2008; 11: 522-535.