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Squat Movement Analysis of Futsal Players with Leg Injury History: A Biomechanics Review

Ulfatul Azizah Awaliyyah, Fajar Awang Irawan*

[1]Departement of Sport Science, Faculty of Sport Science, Universitas Negeri Semarang

*Correspondence: E-mail: ulfatulazizah@students.unnes.ac.id

ABSTRACT

The aim of this study was to analyze squat movements of futsal players who have leg injury history. The research method used in this study was descriptive analytics with a one-shot case study design. The samples were given one treatment and then were observed to obtain the results of the treatment. This study involved 9 Kapten Muda Futsal Academy futsal players who had a history of leg injuries as samples selected using purposive sampling technique. The results showed the mean of spinal tilt angle 65.56 ± 6.19 degrees, hip angle 80.44 ± 6.64 degrees, knee angle 67.52 ± 10.35 degrees, and ankle angle 54.66 ± 6.50 degrees. It concludes that squats performed by Kapten Muda Futsal Academy futsal players who had leg injury history were not optimal and had not been able to reach the 90 degree squat position. This study found that poor ankle mobility, an angle less than 35 degrees, and the history of knee injury will get a squat with a body tilt position leaning forward and backward, causing the squat movement to be not optimal. The optimal squat technique should have feet shoulder width apart and knee movement no further forward than the toes, gaze in a forward position, and do the squat position at full depth 115-125 degrees. However, this study only used one camera to record squat movements to analyze hip, spine, knee, and ankle angles. It is hoped that future studies analyze the squat movement at a full depth position of 125 degrees.

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INTRODUCTION

Physical activity refers to any bodily movement that results in increased energy expenditure. Sports injuries may arise from traumatic events or from repeated training with excessive loads over an extended period of time (Setiawan, 2011). These injuries can be caused by three main factors: internal factors, external factors, and continuous overload during training. Internal factors are those originating from within the body, such as anatomical imbalances, improper movements during training, or muscle weakness. External factors include inadequate facilities, collisions or physical contact with other players, and poor field conditions. Sports injuries are often characterized by inflammation, which manifests as redness, swelling, heat, pain, and reduced function.

All forms of physical activity, especially sports, inherently carry the risk of injury. This is due to the dynamic movements involved, which engage various body structures such as joints, muscles, and bones. Sports injuries may result from physical stress, technical errors, collisions, or excessive physical exertion (Hardyanto & Nirmalasari, 2020). Futsal, as a high-intensity sport, demands significant physical strength and endurance. Players are required to move constantly—running, dribbling, passing, and kicking the ball—all of which depend heavily on lower-body strength (Kadir et al., 2022). Research by Kadir et al., (2022) found that the risk of injury in futsal is relatively high and frequently occurs during both training and matches, either intentionally or unintentionally. Location-wise, the highest incidence of injuries in futsal occurs in the lower legs. Approximately 85.2% of injuries affect the lower extremities, with the ankle being the most common site at 40.7%.

Muscle injuries, particularly in the lower extremities, are prevalent among futsal players. This condition, often referred to as muscle cramps, is characterized by excessive pulling of muscles and their tendons due to substantial stress from intense and prolonged physical activity (Lestari, 2022). According to Herdiandanu & Djawa (2020), muscle injuries account for 31% of all sports-related injuries. Within the legs, the risk of muscle injury reaches 77%, including 21% in the thigh muscles, 23.1% in the knee muscles, and 38% in the ankle. In futsal players, the highest percentage of muscle injuries occurs in the lower body extremities, with the hamstrings and quadriceps being the most commonly affected muscles (Nirmalasari et al., 2020).

Efforts to prevent injuries are crucial to minimize their severity for athletes, allowing them to continue playing and achieve success. Injury prevention can be achieved through various exercises aimed at strengthening athletes' muscles. In futsal, leg muscles are fundamental for passing, running, and shooting techniques to score goals. Therefore, exercises to improve leg muscle strength are essential. Squat movements can also serve as a rehabilitation program to enhance leg muscle strength following injuries. Squat exercises are a form of resistance training used to increase strength, particularly in the leg muscles, and can be performed with or without external weights (Hendriadi, 2019). Research conducted by Saudini & Sulistyorini (2017), it states indicates a significant positive effect of squat exercises on increasing the power of futsal players' leg muscles. Consequently, squat movements, besides improving athletic performance, can also be employed as a preventive measure against leg injuries in futsal players through biomechanical analysis. Furthermore, squat movements are used to assess an individual's functional movement capabilities.

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Biomechanical analysis offers numerous benefits, as it provides extensive information for analyzing various human movements, particularly to enhance athlete performance and reduce the risk of injury (Faizah & Herdyanto, 2019). In sports, biomechanical analysis helps identify effective and efficient movement patterns and provides recommendations to minimize injury risk (Irawan & Long-Ren, 2019). This study aims to analyze squat movements in futsal players with a history of leg injuries. The researchers hope that the findings will contribute to public knowledge and serve as a reference for future studies.

METHODS

This study employed a descriptive-analytical approach using a one-shot case study design. The sample consisted of male futsal players aged 15-20 years from the Kapten Muda Futsal Academy who had a history of leg injuries. The sampling method used was purposive sampling.

Participants

A total of nine male futsal players with a history of leg injuries participated in the study. Participants were selected through purposive sampling based on predetermined criteria: male players aged 15-20 years who had experienced leg injuries to be tested by doing squat movements.

Table 1. Anthropometric Data of Kapten Muda Futsal Academy futsal players

Gender	N	Weight (Kg)	Height (Cm)	BMI
Male	9	64,77 ± 13,45	1,71 ± 0,05	21,84 ±3,67

Based on the anthropometric data of the nine male futsal players, the average body weight was 64.77 ± 13.45 kg, the average height was 1.71 ± 0.05 cm, and the average Body Mass Index (BMI) was 21.84 ± 3.67.

Sampling Procedures

The sampling technique used was purposive sampling. Purposive sampling is a technique where research samples are selected based on specific considerations and objectives aligned with the characteristics of the research subjects (Mustafa & Masgumelar, 2006). The selection criteria for this research included futsal players from the Kapten Muda Futsal Academy aged 15-20 years who frequently participated in training and had a documented history of leg injuries. This was evident during leg muscle strength training and their suboptimal performance of squat movements. A total of 9 players met these criteria.

Materials and Apparatus

Specific equipment and tools were required to analyze the research variables. This research was supported by Kinovea 0.9.5 software, which was used to analyze recorded videos. The tools and equipment used included: camera, camera tripod, stationery, laptop with Kinovea 0.9.5 software, stopwatch, and scales.

Procedures

The research was conducted at Wujil Stadium. Prior to testing, participants received detailed instructions and performed a sufficient warm-up. The research procedures were as follows: (1) preparing stationery to record test participant data, tripods, and iPhone 11 mobile cameras for recording squat movements; (2) positioning the prepared camera perpendicular to the participant and initiating recording when the squat began; (3) instructing participants to perform squat movements to a maximum knee flexion of 90 degrees (with knees aligned parallel to the hips). Following data collection, the optimal trials were analyzed using Kinovea software version 0.9.5 to extract data on step length, time, and movement angle. The research design employed in this study was a descriptive analytical one-shot case study,

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where the sample underwent a single observation after the "treatment" (which in this case is the performance of the squat) to obtain the results of the treatment given.

Design or Data Analysis

The method used in this research was descriptive analytical with a one-shot case study design, where the sample performed a single test squat and was subsequently observed. Descriptive analytical research focuses on motion analysis, aiming to explain aspects such as distance, speed, body segment movements, time, and angles during squatting (Soendari, 2012). Video data were analyzed using Kinovea software version 0.9.5 to obtain data such as step length, time, and angles of movement.

RESULTS

The results of this study included data from 9 players of the Kapten Muda Futsal Academy, with indicators consisting of age, height, weight, and BMI (Body Mass Index). Motion analysis was performed using Kinovea 0.9.5 software to analyze the squat movements of players with a history of leg injuries. The motion analysis data are presented in Table 2, divided into the eccentric (descending) and concentric (ascending) phases of the squat movement.

Table 2. Squat Motion Analysis (N=9)

N=9	Mean ± SD	Min	Max
Time (s)	2,08 ± 0,26	1,8	2,64
Stride Leg (cm)	6,54 ± 0,93	5,32	8,6
Eccentric Phase			
Eccentric Phase Time *(s)*	1,06 ± 0,12	0,9	1,3
Body Tilt Angle (°)	65,56 ± 6,19	55,2	73,7
Hip Angle (°)	80,44 ± 6,64	46,6	63,9
Knee Angle (°)	67,52 ± 10,35	66,4	88,5
Ankle Angle (°)	54,66 ± 6,50	46,3	85,7
Consentric Phase			
Consentric Phase Time (s)	1,02 ± 0,14	0,83	1,33

Based on Table 2, the squat motion analysis using Kinovea 0.9.5 software from the 9 Kapten Muda Futsal Academy players with a history of leg injuries showed an average eccentric phase time of 1.06 ± 0.12 seconds and an average concentric phase time of 1.02 ± 0.14 seconds. During the eccentric phase, the average body tilt angle was 65.56 ± 6.19 degrees, the average hip angle was 80.44 ± 6.64 degrees, the average knee angle was 67.52 ± 10.35 degrees, and the average ankle angle was 54.66 ± 6.50 degrees. The division of squat movement phases is illustrated in Figure 1.

Figure 1. Squat Movement Phase
(Source: Buckingham, 2004)

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When performing squat movements, it is generally divided into two phases of movement, namely the eccentric phase (descending) and the concentric phase (standing) with the position of the feet shoulder-width apart. The eccentric phase involves hip flexion, knee flexion, ankle dorsiflexion, and slight spinal flexion. The concentric phase involves hip extension, knee extension, ankle plantarflexion, and slight spinal extension. Maintaining proper body position, particularly spinal tilt and leg alignment, is crucial for a correct squat technique.

Proper and optimal squatting technique is believed to reduce the risk of injury in athletes and contribute to the development of specific muscles (Comfort & Kasim, 2007). Comfort & Kasim (2007) also noted that squats are not only a leg strengthening exercise but can also be safer than other exercises. Consistent use of squat exercises in leg strengthening programs can benefit Anterior Cruciate Ligament (ACL) strength and potentially reduce the risk of such injuries.

According to Widjaja (2019), during squats, the hips move backward, and the knees move forward. In the eccentric phase, the knees and hips move in forward and backward directions, respectively. If this coordinated movement does not occur, and the knees or hips move only downward without the backward hip motion, the squat movement becomes suboptimal, potentially causing the heels to rise. The analysis of the 9 samples revealed that they were able to perform squat movements with their hips and knees crossing the designated marker lines.

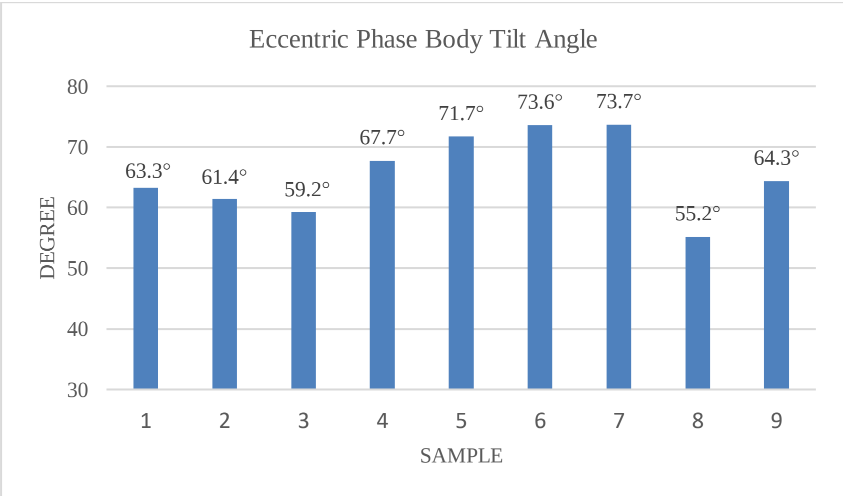

Figure 2. Eccentric Phase Body Tilt Angle

When doing squats, it is also necessary to pay attention to the body in the back and hip position. In this position, the back and hips are in a straight line or parallel and there is no hunched position in the lower back. The players with a history of leg injuries exhibited an average body tilt angle of 65.56 ± 6.19 degrees during the eccentric phase. Figure 2 illustrates the body tilt angles during the eccentric phase for the 9 players with a history of leg injuries. According to Squat University, the typical body tilt angle during the eccentric phase of a squat in individuals without injury is 55 degrees. This suggests that the futsal players from the Kapten Muda Futsal Academy did not achieve an optimal body tilt angle during the eccentric phase of their maximum squat. The participants displayed a range of body tilt angles, including leaning forward and maintaining a more upright position. The tilt of the spine position that is so leaning forward will make a greater contribution from strong back muscles.

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The study mentioned at knee flexion for 60 degrees, the muscle moment of the peak hip ectensor was generated in all attitude groups. In the study of Escamilla et al (2001) stated that when the knee flexion position is at 50 degrees there is a contraction of the hamstring muscles.

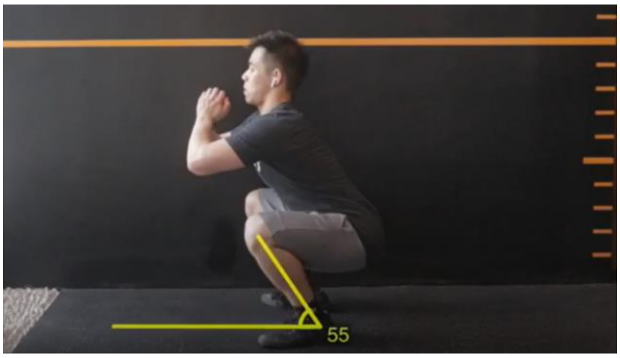

Figure 3. Optimal Ankle Mobility Degree Angle
(Source : Widjaja, 2019)

Suboptimal squats can also result from limited range of motion in the thigh muscles and poor ankle mobility. According to research by Schoenfeld (2010), a high level of mobility in the ankle is needed to help balance and control the body during the eccentric and concentric phases of squatting. The data results from the analysis that has been carried out on the sample have an ankle angle with an average of 54.66 ± 6.50 degrees. According to Ghodrati (2023), ankle mobility can affect squat movements. If the ankle mobility is good, it will affect the flexion movement during the squat, the knee can move forward when descending parallel to the toes during the eccentric phase and can support the body when squatting at 90 degrees. Meanwhile, if the athlete or sportsman has a history of ankle injury or has poor ankle mobility, there will be pressure on the lower back and a greater number of lumbar. Poor ankle mobility can restrict the forward movement of the knee, hindering the ability to reach a 90-degree squat position. According to (Budiarto, 2023), the optimal ankle mobility during squat movement is 35 degrees. If it is less than 35 degrees and the knee cannot move to the down position and forward parallel to the toes then it needs to be a concern in the ankle. In all nine samples, the analysis results have good results to achieve optimal ankle mobility.

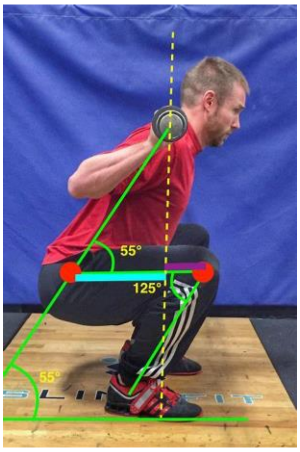

Figure 4. Squat Angle at 90 Degrees
(Source : Horschig, 2016)

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According to study by Schoenfeld (2010) the knee, especially the ACL (Anterior Cruciate Ligament), is a primary joint stabilizer. During squatting, the main muscles around the knee are the quadriceps femoris (vastus lateralis, vastus medialis, vastus intermedius, and rectus femoris), which extend the knee during the concentric phase and resist eccentric knee flexion. The knee's primary role during squats is to prevent anterior tibial translation, especially at low flexion angles. It also limits internal and external rotation and inhibits varus or valgus movements. The sample had an average knee angle of 67.52 ± 10.35 degrees. Research on squat and leg press biomechanics indicates that patellofemoral joint (PFJ) forces increase with greater knee flexion. Therefore, individuals with PFJ pain might benefit from limiting the range of motion to a more "functional" 50° knee flexion, if specific to their sport. The knee should not extend past the foot, in the sagittal or frontal plane (either medial or lateral above the knee).

When performing squat movements, body balance is required to obtain a body tilt angle position. The shape of the foot is one of the most important parts in exercise and affects the musculoskeletal and skeletal structures of the foot, namely the arch foot and arcus pedis (Irawan et al., 2020b). The risk of injury that occurs which causes a decrease in performance during exercise or when competing is also caused by the shape of the performance during or when competing in the ankle and knee is also caused by Arcus Pedis. According to research Irawan et al., (2020a) abnormalities in the arcus pedis that do not grow normally cause balance disturbances, unstable motion, continued deformities, complaints of fatigue if walking for a long time, shoe heels quickly run out of base, excessive surface injuries, and can cause pain, potentially decreasing performance during exercise or competition. A normal foot shape contributes to increased body balance during squat movements, while a higher degree of flatfoot is associated with lower levels of dynamic balance (Sahabuddin, H., 2016).

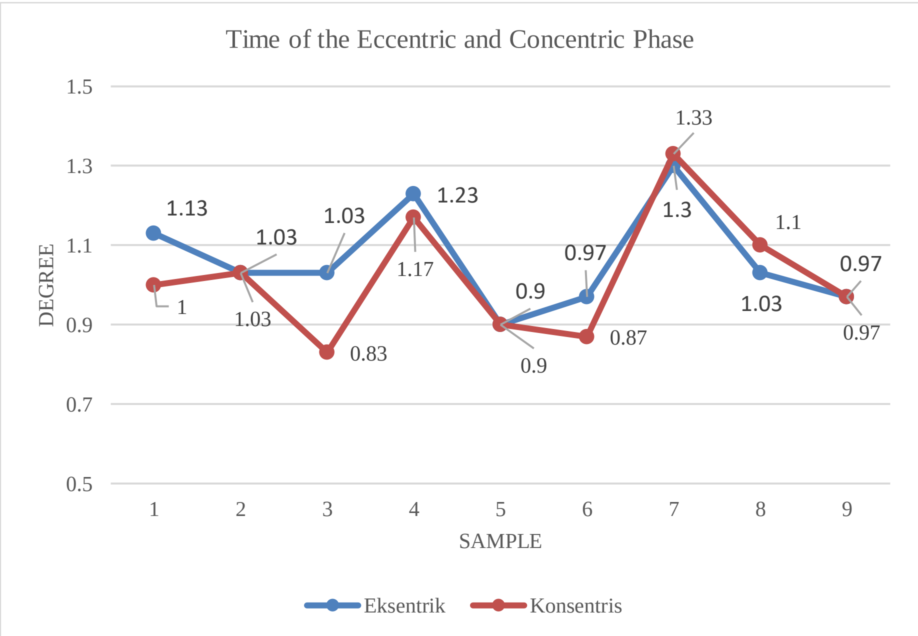

Figure 5. Time of the Eccentric and Concentric Phase

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Analysis of the squat movement revealed a total average time of 2.08 ± 0.26 seconds for the 9 participants with leg injuries. The average eccentric phase time was 1.06 ± 0.12 seconds, and the average concentric phase time was 1.02 ± 0.14 seconds. In bodyweight squats, it is reported an eccentric phase time range of up to 2 seconds and a concentric phase time ranging from 1 to 3 seconds (Schoenfeld, 2010). The analysis results indicate that the average times for both phases in this study were relatively good, as no participant reached 3 seconds during the concentric phase.

DISCUSSION

Squats are one of the most common exercises that can be used to strengthen the quadriceps femoris muscle. Zawadka et al (2020) the use of squats in physical therapy and sports training to enhance leg muscle strength due to the involvement of numerous muscles and joints in the lower extremities. The quadriceps femoris exhibits maximal activity during full contraction at a 90-degree knee flexion angle. Maintaining this muscle activity at a constant level is possible with squat depth reaching 90 degrees (Gawda et al., 2017). Optimal squat performance offers significant benefits, as many daily activities require coordinated action of multiple muscle groups. According Comfort & Kasim (2007), the optimal squat technique ensures a wide stance of the feet in a shoulder-width position, knee movement is not more forward than the toes, the view is forward (not down), and the squat position is at a full depth of 115-125 degrees. The depth of the squat is one of the variables used to assess whether the squat movement performed is optimal or not (Bryanton et al., 2012). Inability to achieve the specified depth may indicate underlying issues, such as limitations due to a history of injury affecting joint and muscle mobility. Squat training is a valuable exercise for improving quality of life by engaging multiple muscle groups in a single movement. Zawadka et al (2020) found that knee mobility makes the most significant contribution of all muscles and joints to determine the optimal squat position that can be performed. Knee problems can negatively impact squat performance. Individuals with a history of knee injury may find it difficult to perform squats at an optimal 90-degree depth. Joint mobility and muscle weakness are significant factors influencing the success and optimality of squat movements (Macrum et al., 2012).

Biomechanical motion analysis of squats is valuable for providing feedback on movement execution during the eccentric and concentric phases. Furthermore, this analysis can reveal the current state of an individual's mobility, whether it is good or impaired. Through biomechanical analysis, athletes can receive movement recommendations to enhance movement efficiency and effectiveness, ultimately leading to improved performance to achieve achievements (Irawan et al., 2021). Optimal squat movements can reduce the risk of injury, improve joint mobility, increase leg muscle strength, and enhance functional movement abilities, particularly in the lower extremities. Squats serve as both a leg strengthening exercise and a rehabilitation tool. This study focused on kinematic data, without the support of kinetic data. Video capture was limited to a single lateral view, used to analyze the angles of the hips, spine, knees, and ankles.

CONCLUSION

The analysis of squat motion in Kapten Muda Futsal Academy players with a history of leg injuries revealed an average spinal tilt angle of 65.56 ± 6.19 degrees, hip angle of 80.44 ± 6.64

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degrees, knee angle of 67.52 ± 10.35 degrees, and ankle angle of 54.66 ± 6.50 degrees. Limited ankle mobility (less than 35 degrees) can lead to excessive forward or backward body tilt during squats, resulting in suboptimal movement patterns. Furthermore, individuals with a history of knee injury tend to exhibit non-optimal squat mechanics and may struggle to achieve a 90-degree squat depth. Conversely, executing squats with proper technique at a 90-degree knee angle can enhance leg muscle strength, providing support for the upper body and potentially improving futsal performance. A key limitation of this study was the use of a single camera for recording, used to only analyze the angles of the hips, spine, knees, ankles. Future research should aim to analyze squat movements at a full depth of 125 degrees to provide a more comprehensive understanding.

AUTHORS' NOTE

The authors declare that there is no conflict of interest regarding the publication of this article. The authors confirmed that the paper was free of plagiarism.

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