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The back squat is one of the most commonly used exercises in strength and conditioning. It has major value for its ability to develop lower-body strength and improve overall athletic performance. It involves lowering the body by flexing the hips, knees and ankles before returning to a standing position, typically with a barbell placed across the upper back. Due to the large amounts of muscle involved, the back squat is considered a key movement for increasing force production in the lower body. The exercise primarily targets the quadriceps, glutes and hamstrings, while the core muscles work to stabilise the trunk and maintain posture throughout the movement (Comfort et al., 2010).

The ability to produce high levels of force through the legs is essential for many sporting actions. Developments in squat strength have been linked to enhanced performance in activities such as sprinting, vertical jump and faster changes of direction, as these movements rely on the efficient generation and transfer of force from the ground (Suchomel et al., 2016). For the reason the back squat is included in training programmes across a range of sports, from team sports to individual power based events. The movement also has a strong functional engine, as it reflects everyday and sporting tasks that involve lowering and raising the body under load.

Although the back squat has many benefits, the effectiveness of the movement depends heavily on correct technique. Poor movement patterns, such as excessive forward trunk leans, knee valgus, or rounding of the lower back, can increase stress on the joints and surrounding tissues. Research has shown that poor squat mechanics may contribute to injuries, particularly in the knee and lumbar spine (Schoenfeld, 2010). As a result, proper coaching, appropriate loading and progressive development are crucial to ensure the movement is performed safely and effectively. When performed correctly, the back squat not only enhances strength and performance but also plays an important role in reducing injury risk by improving movement control and lower body stability.

The back Squat is a complex, multi-joint movement that requires coordinated action across the hips, knees and ankles, alongside trunk stabilisation. The exercise can be split into two main phases: the eccentric (lowering) phase and the concentric (lifting) phase. During the eccentric phase, the hips and knees flex while the ankles move into dorsiflexion as the body lowers under control. This phase is important for absorbing force and maintaining balance, with the glutes and quads working eccentrically to control the descent. The trunk muscles, including the erector

spinae and abdominal muscles, act isometrically to maintain a neutral spine and prevent excessive forward lean (Schoenfeld, 2010).

At the bottom position of the squat, the lifter reaches peak joint flexion, with the depth of the squat influencing both muscle activation and joint loading. The greater the squat depth, the more activation develops in the glutes and improved overall strength development, as long as the proper technique is maintained (Bryanton et al., 2012). From this position, the concentric phase begins, where the hips and knees extend, and the ankles plantarflex to return the body to a standing position. The quads play a major role in knee extension, while the glutes are the primary contributor to hip extension. The hamstrings assist with hip extension and help stabilise the knee joint throughout the movement.

Effective force production during the back squat relies on maintaining proper alignment and control throughout the lift. Keeping the barbell position over the midfoot helps ensure efficient force transfer through the kinetic chain and reduces unnecessary stress on the joints. Excessive forward trunk lean or knee valgus can alter joint loading patterns and increase injury risk, particularly at the knee and lower back (Escamilla, 2001). Additionally, ankle mobility and hip stability play an important role in achieving adequate squat depth while maintaining balance and posture. Overall, the back squat requires a high level of neuromuscular coordination to synchronise multiple joints and muscle groups. When performed with correct technique, the movement promotes efficient force production, improves movement mechanics and contributes to the development of strength and power that can be transferred to athletic performance.

The aim of this report is to analyse the biomechanics of the back squat using Dartfish video analysis to assess movement technique, identify areas affecting movement efficiency and highlight any potential injury risks. The methods that were used consisted of biomechanical data being collected from one recreationally trained male (age 26, height 178cm, weight 95kg) who had previous experience performing the back squat as part of a regular resistance training program. The participant reported no current injuries and completed a warm-up prior to testing, consisting of light aerobic activity followed by muscle activation and progressive squat sets with lighter loads to prepare for the movement.

Video footage was recorded using a smartphone camera and analysed using Dartfish motion analysis software. The camera was positioned side on to the participant at approximately hip height and placed perpendicular to the direction of the movement to allow for sagittal plane analysis. This setup enabled clear observation of the legs and trunk movements, as well as the trajectory of the barbell. Joint angles and bar path were assessed in the sagittal plane, as this plane provides key information regarding squat depth, trunk position and overall movement efficiency.

The participant performed three repetitions of the back squat using 60-70% of their one rep max, each repetition was performed with a controlled tempo and consistent technique. The second rep was selected for analysis to reduce the influence of adjustment or fatigue. The primary variables measured included the hip angle at the bottom position, knee angle, trunk angle, squat depth and barbell path. These measures were used to assess the quality of the movement and identify any technical deviations that may affect performance or increase injury risk. There were some limitations that should be considered. The analysis involved a single participant, which limits the ability to generalise the findings. The use of two-dimensional analysis does not capture movement in the frontal or transverse planes. No data on ground reaction forces or joint loading were collected, meaning the analysis was limited to observational kinematic measures only.

Table 1 Squat results - Joint angles and movement during the back squat

Phase	Knee Angle	Hip Angle	Trunk Angle	Bar Path Position	Depth
Descent	120	115	30	Slight forward	Above parallel
Bottom	95	105	36	Over mid foot	Below Parallel
Ascent	135	140	28	Vertical	Rising

Dartfish analysis was used to examine joint angles and barbell movement during the back squat. The second repetition was selected for detailed analysis as it represented the most consistent movement pattern. Key positions during the descent, bottom and ascent phases are presented in Table 1. During the eccentric phase, knee flexion increased progressively, reaching 120 degrees at mid-descent. Hip flexion at this point was measured at 115 degrees, while trunk inclination was recorded at 30 degrees relative to vertical. The barbell showed a slight forward displacement during the early descent but remained close to the mid-foot position.

At the bottom position, peak knee flexion was measured at 95 degrees. Hip flexion reached 105 degrees, indicating a deep squat position. Squat depth was slightly below parallel, with the hip joint positioned just below the level of the knee. Trunk inclination increased to 36 degrees relative to vertical at this point. The barbell was positioned directly over the midfoot, indicating a balanced bottom position. During the concentric phase, coordinated hip and knee extension was observed. Knee angle increased to 135 degrees at mid ascent, while hip angle increased to 140 degrees. Trunk inclination is reduced to 28 degrees as the participant returns towards an upright position. Bar path during the ascent remained vertical with minimal horizontal deviation.

Knee tracking remained aligned with the toes throughout the movement, with no visible medial collapse observed. Movement appeared symmetrical between the left and right sides, with no obvious lateral shift of the hips or uneven weight distribution. Joint angles and movement patterns were consistent across all three repetitions.

A. Movement efficiency

An efficient squat technique is characterised by a relatively vertical bar path and coordinated joint contribution from the hip and knee extension. In the present analysis, the barbell remained close to a vertical trajectory throughout the movement, with only a small forward displacement during the early eccentric phase before returning over the mid foot during ascent. Maintaining the bar over the mid foot is considered optimal, as it allows force to be transferred efficiently through the lower limbs while minimising unnecessary joint stress.

Peak knee flexion of 95 degrees and hip flexion of 105 degrees indicated a balanced contraction between the quads and glutes. This level of joint motion suggests that both the knee and hip extensors were involved in force production rather than the movement being dominated by a single joint. Squat depth was shown to be slightly below parallel, which is generally associated with better lower body muscle activation and improved strength development (Bloomquist et al., 2013).

B. Comparison to literature

The joint angles observed in this analysis fall within ranges commonly reported in the literature for effective squat performance. Research suggests that full squats typically involve knee flexion between 90 and 120 degrees, depending on injury and squat style (Escamilla, 2001). The measured knee angle of 95 degrees reflects appropriate squat depth. Maintaining a neutral spine throughout the movement is widely recommended to reduce stress on the lumbar structures and allow efficient force transfer (McGill, 2007). Visual analysis indicated that spinal alignment remained stable, with no visible lower back rounding during either the eccentric or concentric phase.

Previous research has also shown that increased trunk inclination shifts the external movement demand toward the hip joint, increasing the contribution of the glutes and hamstrings (Schoenfield, 2010). The trunk angle observed in this analysis is consistent with a typical back squat pattern and does not appear excessive. Overall, the movement characteristics observed align closely with biomechanical recommendations for safe and effective squat technique.

C. Injury risk considerations

Although the overall technique appeared controlled, several factors observed during the analysis have potential implications for injury risk. Increased trunk inclination has been associated with greater lumbar shear and compressive forces, which may increase stress on the lower back, especially under heavier loads or with reduced trunk stability (McGill, 2007). While the trunk angle in this analysis was moderate, excessive forward lean during higher intensity lifts could increase spinal loading (Schoenfeld, 2010). A slight forward bar displacement was also observed during the descent. Moving the bar anterior to the mid foot increases the horizontal distance between the load and the hip and lumbar spine, increasing joint moments and mechanical demand on the posterior chain (Escamilla, 2001). This may also reduce the movement efficiency if the bar path becomes inconsistent.

Knee alignment remains stable, with no visible valgus collapse. This is important, as dynamic knee valgus has been linked to increased anterior cruciate ligament (ACL) loading and a higher risk of lower body injury (Hewett et al., 2005). Movement symmetry between sides further suggests good neuromuscular control.

Squat depth was slightly below parallel, which is generally considered safe when performed with good technique. Research has shown that deeper squats do not increase knee injury risk and may reduce shear forces at the knee compared with partial squats (Hartmann et al., 2013). However, good hip and ankle mobility is required to achieve this depth without excessive trunk compensation. Overall, the main technical considerations were the slight forward bar displacement and moderate trunk lean. While these were not excessive at the observed load, they may become more significant as training intensity increases, showing the importance of ongoing technique monitoring.

D. Limitations and practical applications

Several limitations should be considered when interpreting these findings. First, the analysis was based on a single participant, which limits the ability to generalise the results to other individuals. Second, Dartfish analysis was conducted in two dimensions within the sagittal plane, meaning the movement in the frontal and transverse planes could not be fully assessed. Some rotational movements may have been overlooked. In addition, no kinetic data were collected. Without force plate analysis, it was not possible to quantify joint loading, ground reaction forces or internal joint movements. The squat was also performed using a moderate load, and movement patterns may differ under heavier or max rep conditions.

Despite these limitations, Dartfish provided a practical and accessible method for evaluating squat technique in a field-based setting. The ability to measure joint angles and assess bar path frame by frame allows coaches and practitioners to identify technical issues that may not be visible in real time. This type of analysis can be used to provide targeted feedback, support

technique development, and monitor changes over time, making it a valuable tool within strength and conditioning practice.

In conclusion, this report analysed the biomechanics of the back squat using Dartfish video analysis to assess movement efficiency and identify potential injury risk. The participant demonstrated a generally effective movement pattern, with a near vertical bar path, controlled trunk position and squat depth below parallel. Joint angles observed at the hip and knee indicated a balanced contribution between the primary lower body muscle groups, supporting efficient force production. Only minor technical considerations were identified, including a slight forward bar displacement and moderate trunk inclination, which may become more relevant under heavier loads. Despite the limitations, the analysis provided valuable insight into squat technique. Overall, Dartfish proved to be a practical and effective tool for movement assessment and for supporting coaching feedback within a strength and conditioning environment.

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