BRIEF REVIEW

Squatting Kinematics and Kinetics and Their Application to Exercise Performance

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Abstract

Schoenfeld, BJ. Squatting kinematics and kinetics and their application to exercise performance. *J Strength Cond Res* 24(12): 3497–3506, 2010—The squat is one of the most frequently used exercises in the field of strength and conditioning. Considering the complexity of the exercise and the many variables related to performance, understanding squat biomechanics is of great importance for both achieving optimal muscular development as well as reducing the prospect of a training-related injury. Therefore, the purpose of this article is 2-fold: first, to examine kinematics and kinetics of the dynamic squat with respect to the ankle, knee, hip and spinal joints and, second, to provide recommendations based on these biomechanical factors for optimizing exercise performance.

Key Words squat, biomechanics, kinetics, kinematics

Introduction

The squat is one of the most frequently used exercises in the field of strength and conditioning. It has biomechanical and neuromuscular similarities to a wide range of athletic movements and thus is included as a core exercise in many sports routines designed to enhance athletic performance (20,62). It also is an integral component in the sports of competitive weightlifting and powerlifting and is widely regarded as a supreme test of lower-body strength (17,18).

Benefits associated with squat performance are not limited to the athletic population. Given that most activities of daily living necessitate the simultaneous coordinated interaction of numerous muscle groups, the squat is considered one of the best exercises for improving quality of life because of its ability to recruit multiple muscle groups in a single maneuver (22). The squatting movement has close specificity to many everyday tasks (such as lifting packages and picking up children), as well as having an indirect correlation to countless other chores and hobbies.

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The squat also is becoming increasingly popular in clinical settings as a means to strengthen lower-body muscles and connective tissue after joint-related injury. It has been used extensively for therapeutic treatment of ligament lesions, patellofemoral dysfunctions, total joint replacement, and ankle instability (14,56). Moreover, the closed-chain stance required for performance reduces anterior cruciate ligament (ACL) strain (64), making it superior to the knee extension for rehabilitation of ACL injury (21,65).

Performance of the dynamic squat begins with the lifter in an upright position, knees and hips fully extended. The lifter then squats down by flexing at the hip, knee, and ankle joints. When the desired squat depth is achieved, the lifter reverses direction and ascends back to the upright position. This dynamically recruits most of the lower-body musculature, including the quadriceps femoris, hip extensors, hip adductors, hip abductors, and triceps surae (51). In addition, significant isometric activity is required by a wide range of supporting muscles (including the abdominals, erector spinae, trapezius, rhomboids, and many others) to facilitate postural stabilization of the trunk. In all, it is estimated that over 200 muscles are activated during squat performance (66).

Squats can be performed at a variety of depths, generally measured by the degree of flexion at the knee. Strength coaches often categorize squats into 3 basic groupings: partial squats (40° knee angle), half squats (70 to 100°), and deep squats (greater than 100°). However, no standardized measures of quantification have been universally recognized, and terminology can differ between researchers. Other modifying facts associated with the squat involve varying intensity of load, foot placement, speed of movement, level of fatigue, and position of load.

When performed properly, squat-related injuries are uncommon (75). However, poor technique or inappropriate exercise prescription can lead to a wide range of maladies, especially in combination with the use of heavy weights. Documented injuries from squatting include muscle and ligamentous sprains, ruptured intervertebral discs, spondylolysis, and spondylolisthesis (72).

Considering the complexity of the exercise and the many variables related to performance, understanding squat biomechanics is of great importance both for achieving optimal muscular development as well as reducing the prospect of a training-related injury. Therefore, the purpose of this article