Effects of squat amplitude on pelvic tilt and tibial inclination

Abstract

Strength training is commonly performed at two different knee flexion amplitudes: partial (to 90 degrees) or total (to 140 degrees). During these amplitudes, both the pelvis and the tibia are moved to ensure control of the center of gravity and placement of the external overload. Forward or backward movement of the pelvic tilt may indirectly influence the internal load on the spine. Objective: To measure the effect of squat amplitude on pelvic tilt and tibial inclination. Eighteen male subjects (age: 26±6 years, height: 178±7 cm, total body mass: 81.3±11 kg, resistance training experience: 5±4 years) were evaluated. Pelvic tilt and tibial inclination were measured by a digital inclinometer (Max Measure, USA, accuracy:±0.02°, resolution: 0.05°) during isometric squatting at partial and full amplitudes. The digital inclinometer was fixed on the sacrum and on the tibia, with neutral spine position. A paired student t-test and a significance of 5% were used. There were significant differences in pelvic tilt between partial and full amplitudes (+32.4°±10.9 and -21.7°±12.3, respectively, P<0.001). Maximum tibial inclination values were not significantly different between partial and total amplitudes (19.1°±6.6 and 20.1°±7.4, respectively, P=0.225). It was concluded that the partial squat position produces anterior pelvic tilt while the full squat produces backward pelvic tilt. Inclination of the tibia is similar in both amplitudes of the squat.

Keywords: Exercise, posture, amplitude

Introduction

The squat exercise is a multi-joint task, and can be considered fundamental exercise for lower body strength, general fitness, and rehabilitation. Several studies have shown that manipulating the amplitude of the squat exercise results in altered muscle activity however, research on pelvic movements in the squat are limited. Some research methodologies suggest a correct way to perform the squat, but the correct technique is still controversial, with suggestions that the lumbar curve should be maintained throughout the squat, where as others suggest avoiding a rounded lumbar spine. For heavy squats suggest the squat should be performed to full depth as long as the lordotic curve is maintained. The alignment of the pelvis is correlated with spine curvature and it has also been found to influence lifting function, with anterior tilt of the pelvis providing increased trunk muscle activity. The majority of research on squat technique provide no quantified measure or description of the pelvic tilt. Therefore, the purpose of the present study was to measure the effect of squat amplitude on pelvic tilt and tibial inclination.

Materials and methods

Participants

Eighteen male subjects (age: 26±6 years, height: 178±7 cm, total body mass: 81.3±11 kg, resistance training experience: 5±2 years) were evaluated. Subjects had no previous lower back injury, surgery in the lower extremities, and no history of injury with residual symptoms (pain, “giving-away” sensations) in the lower limbs within the last year. This study was approved by the University research ethics committee and all subjects read and signed an informed consent document (#68/2016).

Results and discussion

There were significant differences in pelvic tilt between partial and full amplitudes (+32.4°±10.9 and -21.7°±12.3, respectively, P<0.001, d=0.95, Δ%=33.8%) (Figure 1). Maximum tibial inclination values did not show significant differences between partial and full amplitudes (19.1°±6.6 and 20.1°±7.4, respectively, P=0.225, d=0.14, Δ%=4.9%).
Effects of squat amplitude on pelvic tilt and tibial inclination

The present results demonstrate important differences between partial and full squats based on pelvic tilt. During the partial squat, the pelvis had an anterior tilt, increasing the lordotic position, while the full squat moved the pelvis backward creating lumbar retification.

The back musculature supports the spine in a neutral position. Increased and potentially harmful compressive and shear forces of the lumbar spine may result during intense squat conditions. Therisk of disc herniation is increased during heavy resistance squatting, with both the flexed spine position, and the backward pelvic tilt as a result of excessive stress placed on intervertebral discs.

Spinal flexion and extension have been shown to significantly impact joint kinetics during squat performance. Squatting with a flexed lumbar spine decreases the moment arm for the lumbar erector spinae, reduces tolerance to compressive load, and results in a transfer of the load from muscles to passive tissues, heightening the risk of disc herniation. Moreover, shear forces during squatting have been found to be significantly greater as lumbar flexion increases from the neutral position.

Previous studies have shown that compressive forces increase during excessive lumbar extension. Therefore, it is advisable to maintain a neutral spine throughout performance of the squat, avoiding any excessive flexion or extension. Furthermore, the lack of tibial inclination differences demonstrates that it does not represent a major influence on control of the center of mass during both squat amplitudes.

Conclusion

The partial squat produces anterior pelvic tilt, while the full squat produces backward pelvic tilt. Inclination of the tibia is similar in both amplitudes of the squat.

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Conflict of interest

Authors declares there is no conflict of interest in publishing the article.

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