Different bicycle Q-factor width change lower extremity kinematic variables associated with the risk of knee overuse injuries

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Abstract

Background: Cycling is a non-weight bearing activity that is steady and continuous, and thus it is expected to be associated with a low incidence of non-traumatic injuries. Due to prolonged cycling for exercise and competition, there are particular patterns of overuse injuries in cyclists compared to other sporting activities. Knee overuse injuries are the most common non-traumatic injuries in cyclists (23-50%) (Dettori & Norvell, 2006). Inexperience (Dannenberg, Needle, Mullady, & Kolodner, 1996), prolonged cycling (Weiss, 1985), and incorrect ergonomic adjustment of bicycles (Bakkes, 1993) are significant factors in knee pain and injury. Adjusting the bicycle to the cyclist's body type is a common way of reducing the risk of overuse injuries. However, to date the effect of different Q-factors on lower extremity 3-D kinematics is unknown.

Purpose: The purpose of the present research was to examine the effect of four different Q-factors on 3-D kinematics of lower extremity associated with the risk of knee overuse injuries.

Methods*:* Ten professional road cyclists pedaled at 100% of peak power output with four different Q-factor (Q0 as the standard width, Q0 +1cm (Q2), Q0+2cm (Q3), and Q0+3cm (Q4)). Flexion/extension and abduction/adduction of the hip joint, abduction/adduction of the thigh segment, flexion/extension and abduction/adduction of the knee joint, abduction/adduction and internal/external rotation of the shank segment, and plantar/dorsiflexion of the ankle were captured using the myoMOTION™ system at frequency of 200 Hz (figure 1).

Results: The angle variations of hip flexion/extension and abduction/adduction, femur abduction/adduction, knee flexion/extension and abduction/adduction, shank abduction/adduction and internal/external rotation, and ankle plantar/dorsi flexion during pedaling in different Q-factors are depicted in figures 2a to 2h, respectively. The results of one-way repeated ANOVA using vector analysis in statistical parametric mapping (SPM) has depicted in figures 3a to 3h. The results showed that shank abduction significantly differs by the change in Q-factor during the power phase (6% to 40 % of the pedaling cycle) ($p = 0.006$, Figure 3f). However, the other kinematic parameters did not significantly change by change in Q-factor ($p > 0.05$).

Discussion: Q-factor change had no significant effect on any joint angle in the sagittal plane. Time series graphs show that the effect of Q-factor change on joint angles is smaller in the sagittal plane than in the frontal plane. Time series graphs for flexion/extension of the femur (Figure 2a) and the knee (Figure 2d) are approximately similar at different Q-factors; however, in the case of the ankle (Figure 2h), there is greater dorsiflexion at Q0 compared to the other Q-factors, especially at the beginning of the power phase and throughout the recovery phase. Greater ankle dorsiflexion has been reported in cyclists with knee pain than those without knee pain (Bailey et al., 2003). Therefore, compared to other Q-factors, Q0 could predispose cyclists to a higher risk of knee overuse injury by increasing ankle dorsiflexion. The shank angle along the frontal plane is closer to zero at Q1 than the other three Q-factors, thus having the smallest medio-lateral motion (Figure 2f). The time series graph of frontal-plane knee motion also indicates that, compared to other Q-factors, pedaling at Q0 leads to larger knee abduction (Figure 2e). At Q0, knee abduction is larger and its angle varies between 2° and -6°. Therefore, this Q-factor seems to predispose the knee to higher varus loads.

Conclusion: The results of the present research showed that using different Q-factors can affect the kinematics of lower extremity joints and segments, and this must be done with caution. However, given that using Q1 (2cm increase) reduced kinematic risk factors for knee injury in the participants, this Q-factor is recommended for road cyclists. The results indicated that at Q1, the shank, thigh, and knee have the smallest medio-lateral motion, and thus the least amount of valgus and varus load is applied to the knee. It is recommended that future research measure the

anthropometrics of the cyclists, including pelvis width and Q-angle, and examine the effect of Q-factor change in relation to these characteristics.

Figure 1: the depiction of a subject on the bicycle attached to Technogym ergometer and the location of myoMotion sensors on segments

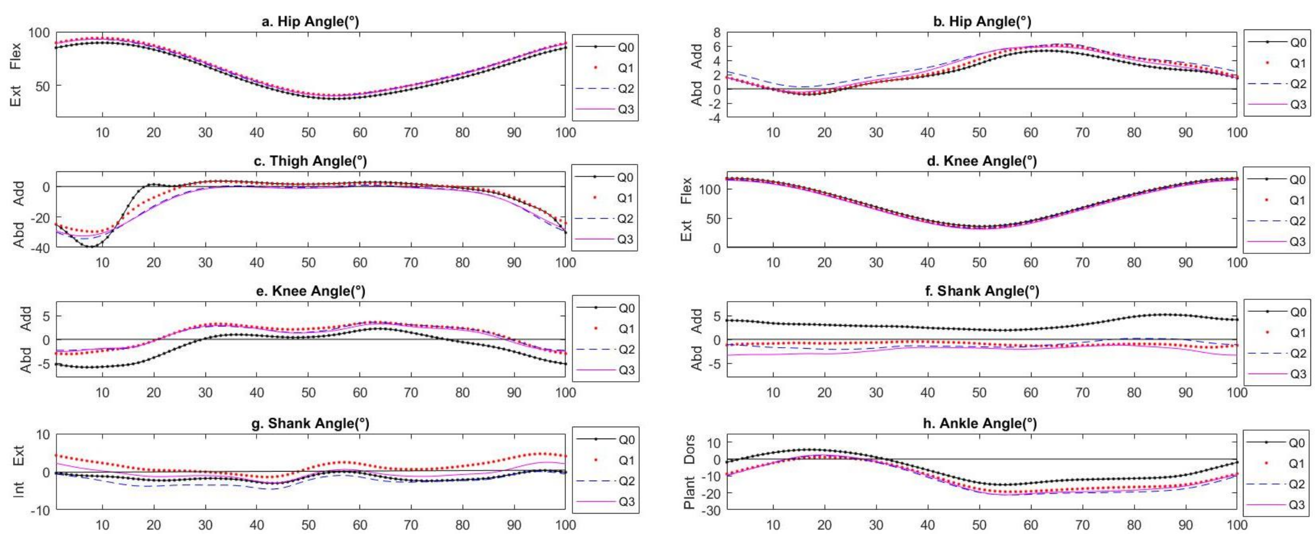

Figure 2. Angle variations of hip flexion/extension and abduction/adduction, femur abduction/adduction, knee flexion/extension and abduction/adduction, shank abduction/adduction and internal/external rotation, and ankle plantar/dorsi flexion during pedalling in differenet Q-factors

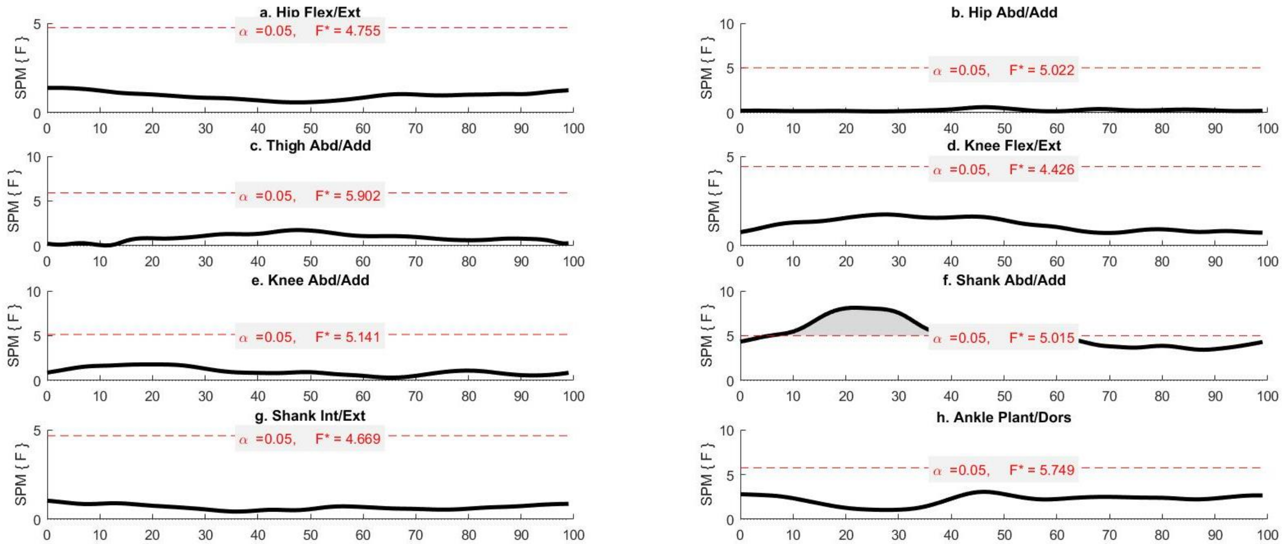

Figure 3. The results of one-way repeated ANOVA in SPM for hip flexion/extension and abduction/adduction, femur abduction/adduction, knee flexion/extension and abduction/adduction, shank abduction/adduction and internal/external rotation, and ankle plantar/dorsi flexion during pedaling in different Q-factors

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