Effects of seat height on muscular pattern and interlimb coordination in cycling

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Abstract

Introduction: The riding position is a key factor for performance in cycling particularly to prevent chronic diseases related to practice. Even though some authors use the crotch length to get the ideal seat height, others base the riding position on knee kinematics [1]. Whereas seat height modifications affect the timing and the kinematic variables, a certain empiricism seems to prevail with the consequence of frequent muscle and joint chronic diseases [2]. Moreover, if the interjoint coordination may be affected by the position [3], the pattern of muscle activation may also be affected, resulting in an imbalance between the anterior and posterior muscle chains [4]. Although osteoarticular structures are directly affected, the neuromuscular system is affected leading to a modification of kinematic, muscular pattern coordination and motor response. Moreover, beyond lower limb kinematics, intergirdle coordination could be crucial to determine a position adapted to the person. The aim of the present study is to establish how interjoint and muscular pattern coordination are affected by various height of seat and whether it affects intergirdle coordination.

Methods: This study was done in accordance with the Helsinki Declaration and has been approved by the local ethics committee. Thirteen experimented bikers participated in the study. They volunteered to participate in the study. They pedaled with their own bike at a rate of 90 t/min on home trainer under three experimental conditions: usual seat height, seat height plus (leg fully extended, pedal down) and seat height minus (same height difference inversely applied). The 3D coordinates of markers placed on body landmarks were recorded using a motion analysis system (Codamotion ™, Charnwood Dynamics Ltd, UK). Muscular activity was recorded through a surface EMG system (Trigno Wireless System ™, Delsys, Boston, MA). From the 3D coordinates, the kinematics of ankle, knee and hip were obtained and time normalized. The angle formed by the scapular and pelvic girdles were computed between the line that connected the two markers of the shoulders and the one that connected the two posterior-superior iliac spines [5]. The relative phase value between scapular and pelvic girdles was assessed by a Continuous Relative Phase algorithm, using a Hilbert transform within the range of $-180° \le CRP \le 180°$. The EMG signal was band-pass filtered. The linear envelope was obtained by low-pass filtering of the rectified signals. Each linear envelope was normalized in time on 100 samples and in magnitude in reference to the highest peak of each gait cycle. A muscle was considered to be active when the signal magnitude was above two standard deviations computed during relaxed upright standing [6]. The start and duration of muscular activity were expressed as a percentage of the cycle duration.
The temporal similarity of the data about joint angular displacement was measured by a Pearson product-moment correlation for each participant. Data were averaged and analyzed through repeated measures ANOVA. The significance level was set at $p < 0.05$.

Results: When the seat height is increased, the range of motion of ankle, knee and hip is lower than the lower heights of seat. The mean value of knee angle indicates that the knee is more extended. However, when the seat height is lower than usual, the range of motion of ankle, knee and hip is higher than the usual height of seat. When the seat height is raised, gastrocnemii and vastii have an earlier activation. Biceps femoris and gluteus medius have a longer activation time as compared to the usual seat height. When the seat height is lower, gluteus medius and tibialis anterior have both an earlier and longer activation, while rectus femoris, biceps femoris and vastii have greater activation time.
The values of the knee-hip relative phase are negative in all experimental conditions. It indicates that the hip is temporally ahead of the knee. They are also close to 0 degree that indicates that both joints are in-phase. Moreover the higher the seat is, the more in-phase the knee and hip are. The values of the ankle-knee relative phase are positive in all experimental conditions. It indicates that the ankle is temporally ahead of the knee. They are also close to 180 degrees that indicates that both joints are out-of-phase. They evolve in opposite directions with the same angular speed. Moreover the lower the seat is, the more out-of-phase the ankle and knee are. The values of the ankle-hip relative phase are positive in all experimental conditions. It indicates that the ankle is temporally ahead of the hip. They are also close to 180 degrees that indicates that both joints are out-of-phase. They evolve in opposite

directions with the same angular speed. Moreover the farther from usual height the seat is, the less out-of-phase the ankle and hip are.
The values of the intergirdle relative phase in frontal plane tend to be close to 0 degree around the usual height of the seat whereas they tend to be close to 180 degrees when the height of the seat is far from usual.

Discussion: Modifications of the seat height involve kinematic changes as expected. Moreover our results highlight neuromuscular modifications involving adaptations revealed through interjoint coordination. Differences in knee kinematic could involve joint instability, leading to chronic disease. When the seat height is higher or lower than usual, the range of motion and its variability are modified as well as the muscular pattern is.
When the height is raised, the knee extension increases. The patella cannot be stabilized by the quadriceps muscle. The vastii - even if they have a greater duration of activation - are stretched as well. When the height is decreased, the knee is more flexed. This causes compression of the patella against the underlying surfaces increased by a longer duration of activity of the quadriceps and biceps femoris. The entire study provides insight on the seat height as a way to reduce muscle stress but also in a sport performance goal. It suggests also to take interjoint and inter girdle coordination as a pertinent indicator of an efficient height of seat.

Key words
seat height, coordination, muscular pattern, cycling position

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