Journal of Electromyography and Kinesiology 27 (2016) 78–86

Contents lists available at ScienceDirect

Journal of Electromyography and Kinesiology

journal homepage: www.elsevier.com/locate/jelekin

Effect of seat positions on discomfort, muscle activation, pressure distribution and pedal force during cycling

Rachita Verma, Ernst A. Hansen, Mark de Zee, Pascal Madeleine *

Physical Activity and Human Performance Group, SMI, Department of Health Science and Technology, Aalborg University, Fredrik Bajers Vej 7, DK-9220 Aalborg, Denmark

ARTICLE INFO

Article history:
Received 3 September 2015
Received in revised form 7 January 2016
Accepted 1 February 2016

Keywords:
Seat height
Seat tube angle
Saddle position
Discomfort
Biomechanics

ABSTRACT

The aim of this study was to measure and analyse discomfort and biomechanics of cycling, i.e., muscle activation, centre of pressure of seat pressure profiles and pedal forces as a function of seat position. Twenty-one recreationally active individuals cycled for 10 min at 100 W on an ergometer cycle using five different seat positions. The neutral position was considered as basic seat position and was compared with upward, downward, forward and backward seat positions. The initial bout was repeated at the end of the recording session. Discomfort increased for upward and backward condition compared with neutral ($P < 0.05$). Normalized surface electromyography from gastrocnemius decreased in the downward and forward position but increased in the upward and backward position. The minimum force became less negative for forward position compared with neutral seat position ($P < 0.05$). The degree of variability of centre of pressure increased in the upward and backward position and the entropy of the centre of pressure of sitting posture for backward position decreased compared with neutral seat position ($P < 0.05$). The present study revealed that consecutive changes of seat position over time lead to increase in discomfort as well as alterations of the biomechanics of cycling.

1. Introduction

Bicycling is a common mode of transportation adopted by many people around the world. One of the most common problem perceived while cycling is discomfort (Baino, 2011). Discomfort is not only reported during prolonged sitting in one position as even short bicycle trips can cause discomfort (Christiaans and Bremner, 1998). Discomfort due to improper seat position adjustment can in the long run lead to non-traumatic injuries (Bressel et al., 2009). So most of the adjustments made to the bicycle are done to obtain a comfortable riding position and proper range of motion for lower extremities (Gregor et al., 2011). Geometric factors like seat height, seat tube angle (STA), body posture and crank length are generally adjusted to optimize the biking seating position. Setting an appropriate seat height is important for discomfort reduction. Fonda et al. (2011) have reported that a change in seat position is perceived positively and result in decrease in discomfort. Various methods have been suggested for the optimal setting of seat height (Bini et al., 2011a). Christiaans and Bremner (1998) have suggested that the seat height preferred for comfort is 106% of crotch height for men and 107% of crotch height for women. STA, defined as the angle between the seat tube and the ground (Umberger et al., 1998), has also an impact on discomfort as larger STA tend to reduce discomfort (Price and Donne, 1997). The biomechanics of cycling and the effects of changes in seat height and STA with regard to discomfort have not been studied thoroughly. De Looze et al. (2003) have suggested that measures like pressure distribution and muscle activation are objective parameters to be anchored with discomfort. Interestingly Gámez et al. (2008) have reported that the highest level of comfort occurs during cycling at a saddle height corresponding to crotch height. In this position, decreases in peak pressure distribution and muscle activation of gastrocnemius and tibialis anterior are also found. Consequently, a better understanding of the biomechanics of cycling including muscle activation, pedal forces and seat pressure distribution may help to design protocols and devices aiming at reducing discomfort.

Bicycle seat interface pressure is major factor in the development of seat discomfort (Bressel and Cronin, 2005). Guess et al. (2006) have shown that loading imposed to soft tissue of buttocks during prolonged seated cycling leads to e.g., numbness and neurological impairment. Interestingly, the degree of variability and complexity of sitting postural control are reported to be correlated with discomfort (Søndergaard et al., 2010). The size of variability of

* Corresponding author at: Physical Activity and Human Performance Group, SMI, Department of Health Science and Technology, Aalborg University, Fredrik Bajers Vej 7 D-3, DK-9220 Aalborg, Denmark. Tel.: +45 99408833; fax: +45 98154008.

E-mail address: pm@hst.aau.dk (P. Madeleine).

http://dx.doi.org/10.1016/j.jelekin.2016.02.003
1050-6411/

the centre of pressure (COP) displacement increase while the structure of variability decrease in relation to the development of discomfort (Søndergaard et al., 2010). So changing seat positions over consecutive bout of cycling may actually result in lower discomfort.

Alteration in body position mainly in terms of change in seat height can affect muscle activation and pedalling (Hug and Dorel, 2009). An increase in seat height results in increased surface electromyography (sEMG) activity in the gluteus medius, medial hamstrings, and gastrocnemius medialis muscle (Ericson et al., 1985). Similarly, a decrease in seat height results in decreased sEMG activity of medial gastrocnemius (Sanderson and Amoroso, 2009). However, only few studies have analysed the effect of STA variation on muscle activation (Bisi et al., 2012). So, the effect of change in STA on muscle activation still needs to be investigated. Pedal forces do not seem to be affected by change in seat position. Change in seat height smaller than ±4% of trochanteric leg length does not lead to significant changes in the resultant pedal forces (Bini et al., 2011b). It has been suggested that while changing seat height, the performed work is balanced among hip, knee and ankle joint leading to similar pedal forces (Bini et al., 2014b). Bini et al., 2014a have also recently reported that an increase in STA does not have major effect on the average total force applied on the pedals. However, to the best of our knowledge the effects of changes in seat height and STA on the biomechanics of cycling have not been studied thoroughly.

The purpose of this study was to assess the changes in discomfort and the biomechanics of cycling as a function of seat positions. The biomechanics of cycling were studied by recording and analysing sEMG activity, pedal forces and COP obtained from seat pressure measurements in normal individuals cycling at 100 W on an ergometer cycle. We hypothesized that discomfort would be varied with change in seat position. Along with discomfort there would be change in the biomechanics of cycling and more specifically in the degree of variability and complexity of sitting postural control.

2. Materials and methods

2.1. Participants

The participants were recreational sportsmen using a bicycle as a regular form of transport. For practical reasons participants with a crotch height less than 80 cm could not be included. Twenty-eight participants volunteered (17 males and 11 females) to take part in the study. However, a total of seven participants could not be included in the analysis. Two participants were excluded from the study as one of them reported back pain while cycling and another one decided to withdrew his participation. The data files from another participant were corrupted and therefore disregarded from the analysis. Furthermore, four participants were excluded from the study as they were unable to follow the instructions during the experiment session. Thus, 21 participants (14 males and 7 females) were included in the analysis. The characteristics of participants were mean ± SD: age: 24 ± 5 yr, height: 1.78 ± 0.07 m, body mass: 74.0 ± 10.3 kg, crotch height: 85.5 ± 3.8 cm. Informed consent was received from participants prior to participation in the experiment. The study was approved by the Ethical Committee of the North Denmark Region (N-20110025). The study was conducted in line with the Declaration of Helsinki.

2.2. Experimental protocol

A familiarization session was conducted one week before the test session to introduce the participants to the experimental protocol. The anthropometric measurements- height, body mass and crotch height of participants were measured. The distance between seat and handlebars were measured by elbow fist method (Christiaans and Bremner, 1998) for each participant during the familiarization session. The SRM ergometer (Schoberer Rad Messtechnik, Jülich, Germany) adjustments for seat height, STA, handle bar distance and level of handle bar were made according to each participant's anthropometry prior to the test session. Here seat height and STA adjustments were done by adjusting vertical height and horizontal distance of seat from crank (Fig. 1a).

The test session lasted for approximately two hours and was composed of six different sitting positions which were derived from subsequent displacements of the seat in vertical and horizontal directions (Fig. 1a).

Seat positions were as follows:

(a) Neutral – Seat height as 106% of crotch height for males and 107% of crotch height for female (Christiaans and Bremner, 1998) and STA 74° (Price and Donne, 1997) which came out as seat height = 90.2 ± 3.6 cm and STA = 74°. This neutral seat position was used to compare with the other four alternative seat positions- upward, downward, forward and backward.
(b) Upward – Seat position was moved 1.9 ± 0.1 cm vertically upward, so that seat height turned out to be 102% of seat height of neutral position, seat height = 92.0 ± 3.7 cm and STA = 74.4°.
(c) Downward – Seat position was moved 1.9 ± 0.1 cm vertically downward, so that seat height turned out to be 98% of seat height of neutral position, seat height = 88.4 ± 3.5 cm and STA = 73.5°.
(d) Forward – Seat position was moved 4.6 ± 0.2 cm horizontally forward, so that STA turned out to be 105% of STA of neutral position, seat height = 89.1 ± 3.5 cm and STA = 77.7°.
(e) Backward – Seat position was moved 4.5 ± 0.2 cm horizontally backward, so that STA turned out to be 95% of STA of neutral position, seat height = 91.6 ± 3.7 cm and STA = 70.3°.
(f) Repeated bout – The last position was a repetition of the position applied in the initial bout. This repeated bout was compared with initial bout. The purpose was to address potential carry over effects.

The order of sitting position (a–e) was counter balanced among participants. Participants were not informed about the sitting position. The participants were allowed to drink water during the recording session. The participants cycled, at freely chosen cadence on SRM cycle ergometer and hands placed on the top of handle bar, with constant power at 100 W for 10 min in each of six positions. The participants rested for 10 min between cycling bouts. The height of the handle bar was kept at the same level of seat as of neutral position and crank arm length was 170 mm.

2.3. Data recordings

Discomfort: The intensity of whole body discomfort i.e. discomfort from head to toe was assessed on a scale anchored from 0 to 10. "0" indicated no discomfort and "10" indicated maximum discomfort perceived while cycling. An electronic visual analogue scale (VAS) (Aalborg University, Aalborg, Denmark) was used to measure the discomfort during cycling. This electronic VAS was synchronized with IMAGO software (part of power force system – Radlabor GmbH, Freiburg, Germany).

sEMG: sEMG was used to record the muscle activation of the right vastus medialis (VM), tibialis anterior (TA) and gastrocnemius (GS) for each participant. We analysed sEMG activity of GS and VM as these muscles have higher level of activation compared with