Journal of Science and Cycling

Breakthroughs in Cycling and Triathlon Sciences

Special number: World Congress of Cycling Science 2015, 1/2 July 2015, Utrech

Editors: Mikel Zabala (PhD)
Greg Atkinson (PhD)

Science & Cycling
1 & 2 juli 2015, Utrecht

CRC

OPEN ACCESS

www.jsc-journal.com

BOOK OF ABSTRACTS Open Access

Bicycle Shoe Insoles and Their Effect on Lateral Knee Movement, Leg Muscle Activation Patterns, and Performance in Experienced Cyclists

A Cole Meyers[1]✉, Elise C Caldwell, Jordan Hirsch, Moataz Eltoukhy, Kevin A Jacobs, Ryan Pohlig, Joseph Signorile

Abstract

Introduction: Riders contact their bicycles at three points: hands, hips, and foot-shoe-cleat-pedal (FSCP) interface (Figure 1). Three techniques are used to achieve fit: experienced-based direct observation, technology-assisted indirect observation, and anthropometrically-based formula fitting (Hogg, 2012). No technique takes full advantage of knowledge concerning the FSCP interface and its potential effects on the mechanics of the legs. Orthotic insoles are an intervention used to correct running mechanics (McMillan & Payne, 2008; Eng & Pierrynowski, 1994), but have received little attention in relation to cycling. This study tested the hypothesis that orthotic insoles in cycling shoes would alter the pedaling mechanics, muscle activity, and submaximal efficiency of healthy, experienced, male cyclists. Additionally, it was hypothesized that the insole that allowed the lowest level of lateral knee movement would produce the greatest improvements in these variables, and be related to arch height

Methods: Nine cyclists were evaluated during four VO_{2max} tests, using four insole conditions (flat [no insole], low, medium, and high arch support) in a random order. To measure arch height variables, foot measurements were taken with the JAK-Tool Arch Height Index Measurement System (AHIMS; JAK Tool and Model, Cranbury, NJ). The AHIMS measured subject foot length, heel-1st metatarsal length, and arch height while sitting and standing. The difference between sitting (unloaded) and standing (loaded) arch variables were calculated to measure "arch collapse". The laboratory cycle ergometer (Velotron Pro, Racermate, Seattle, WA) was configured to replicate the participant's road bike dimensions. High-definition video recordings were used to measure lateral knee movement via retroreflective markers placed at the tibial tuberosities. Muscle activity of the quadriceps and hamstring muscles was measured by surface electromyography at anatomical landmarks (McHugh, Tyler, Greenberg, & Gleim, 2002) using a Noraxon DTS wireless EMG system, and telemetry-based gas analysis determined cycling efficiency (Figure 2). Raw EMG signals were recorded during the last ten seconds of each 2-minute stage. Using pedal revolutions defined by a reed switch, the 5 "middle" pedal cycles of the 10s data collection period were identified. EMG for each muscle for this period was isolated, the root mean square value was calculated and normalized to peak values previously measured. EMG values were then used to calculate a ratio of medial-to-lateral muscle activity for the quadriceps and hamstrings muscle groups. These normalized values were averaged within trials to give one measure to compare across trials (insole conditions). Tests were performed at least 48 hours apart to control for fatigue. The non-flat insole that resulted in the lowest level of lateral knee movement was identified for each leg.

Results: Spearman rank-order correlations showed no relationship between arch variables and this "best fit" insole. Since best fit insole was not the same between feet for most participants, general linear mixed models were run twice, with the best insole for the dominant leg and non-dominant leg identified as the overall "best fit" insoles. When the best fit for the dominant leg was the overall "best fit" insole, it produced effects on dominant knee lateral movement (p=.001) and heart rate at anaerobic threshold (p=.014) (Figures 3&4). The non-dominant "best fit" insole had a significant effect on heart rate at anaerobic threshold (p=.017) (Figure 5). Other measures of submaximal efficiency showed no significant main effects or interactions.

Conclusions: Although the "best fit" insole was not mechanically better than baseline, it was also no worse. It may be that using the rider-identified more comfortable of the two may result in safer and/or more mechanically efficient pedaling motion (Callaghan, 2005). While it should be possible to identify "best fit" by rider characteristics (Nigg, Nurse, & Stefanyshyn, 1999), this study does not suggest arch variables is one of them. The implication of these findings is that orthotic insoles may be an effective intervention to acutely alter pedaling mechanics and upper leg muscle activation ratios about the knee, but have little effect on cycling performance.

References:

Hogg, S. (2012). Perspectives on fitting.
McMillan, A., & Payne, C. (2008). *J Foot Ankle Rsrch, 1.*
Eng, J. J., & Pierrynowski, M. R. (1994). *Phys Ther, 74*, 836-844.
McHugh, M. P., Tyler, T. F., Greenberg, S. C., & Gleim, G. W. (2002). *Journal of Sports Sciences, 20,* 83-91.
Callaghan, M. J. (2005). *J of Bwrk and Mvmnt Ther, 9,* 226–236.

Nigg, B.M., Nurse, M.A., & Stefanyshyn, D.J. (1999). *Med Sci Sprt and Exercise, 31*, S421

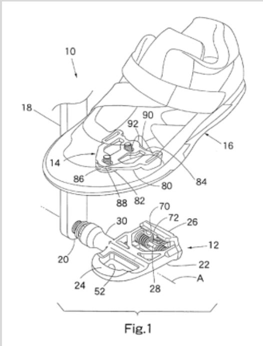

Figure 1: Shimano FSCP interface, patent #US 6925908 B2. The image shows the mechanics of shoe attachment to the pedal system, via cleats attached to the bottom of the shoe.

Figure 2: Subject prepared for exercise trial.

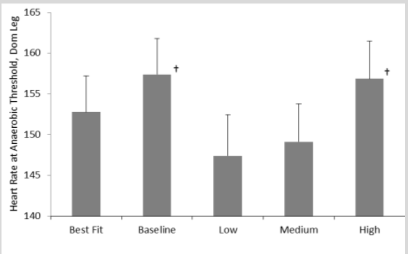

Figure 3: The effects of insole condition on lateral knee movement in the dominant leg. * Significantly higher than “Best Fit”, p<.05.

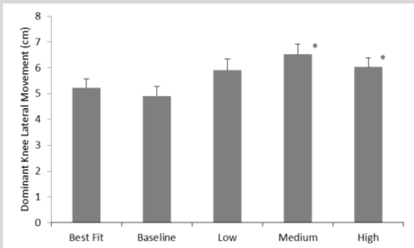

Figure 4: The effects of insole on heart rate at anaerobic threshold (HRAT) for dominant leg. †Significantly higher than "Low" and "Medium" insoles, p<.05.

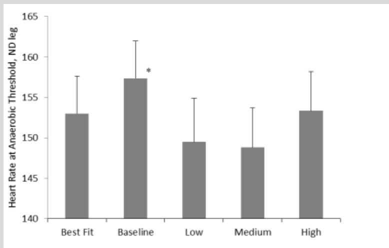

Figure 5: The effects of insole on heart rate at anaerobic threshold (HRAT) for non-dominant leg. * Significantly higher than "Best Fit", "Low", and "Medium" insoles, p<.05.

✉ **Contact email: meyers.amos@gmail.com (**A. Meyers)
[1] University of Miami, Deparment of Kinesiology and Sport Sciences