Abstracts

P1

Biomechanical aspects of road cycling

Koos Jaap van Zwieten[1], KP Schmidt[1], IA Zubova[1], OE Piskun[2], SA Varzin[2]

[1]University of Hasselt, Diepenbeek, Belgium
[2]Peter-the-Great St. Petersburg Polytechnic University, St. Petersburg, Russia

Corresponding author: koosjaap.vanzwieten@uhasselt.be

Introduction and theoretical analysis. Biomechanical analyses of cycling can be realized theoretically by a closed kinematic chain, consisting of elements of the cyclist and elements of the bicycle on either side. These elements are: 1) Frame, 2) Crank, 3) Pedal & Foot, 4) Lower leg, 5) Upper leg, 6) Pelvis. On the frame's saddle, the pelvis is supposed to move rotation-wise only. The mobility of this closed chain results in a total of 3 degrees of freedom (DOF). The chain can be controlled and stabilized by 3 sets of antagonistic muscle groups, namely extensors and flexors of hip, knee and ankle joints respectively.

Practical analysis. In reality, for a racing bike traveling fast, about 80 % the work the cyclist does will go in overcoming air resistance. Therefore road cyclists prefer a so-called aerodynamic position. However, this 'aero position' inevitably implies 15°-20° anterior tilt of the pelvis.

Material and methods. An anterior pelvic tilt of 20° was simulated by means of osteology of the pelvis, starting from its neutral position. It results in a more posterior position of the tuber ischiadicum and a more anterior position of the spina iliaca anterior inferior. Changes of lengths of muscles having their origins on these landmarks were simulated.

Observations. In the optimal aerodynamic position, 20° anterior pelvic tilt results in a 7.5 % increase of the length of the hamstrings (long head of m. biceps femoris and m. semimembranosus) and a 6 % decrease of the length of the m. rectus femoris. These muscles are most active during pedal strokes.

Results and Conclusion. The increase and decrease in length of these muscles in aero position may lead to respectively hamstrings passive insufficiency and m. rectus femoris active insufficiency, as these muscles are now likely to shift away from their plateau region of optimal force (= 100 %).

Discussion. Such imminent muscle insufficiencies are reflected in "thigh injuries" such as "quadriceps and hamstring strains", as diagnosed in cyclists. Therefore, to restore optimal muscle force, Electro Vibro Stimulation (EVS) is strongly recommended.

Unabridged version of the above abstract, including all References:

Biomechanical aspects of road cycling

Koos Jaap van Zwieten [1], K.P. Schmidt [1], I.A. Zubova [1], O.E. Piskun [2], S.A. Varzin [2]

[1] University of Hasselt, Diepenbeek, Belgium
[2] Peter-the-Great St. Petersburg Polytechnic University, St. Petersburg, Russia

Corresponding author: koosjaap.vanzwieten@uhasselt.be

Introduction and theoretical analysis. Biomechanical analyses of cycling can be realized theoretically by a closed kinematic chain (Huson, 1985), consisting of *elements* of the cyclist and *elements* of the bicycle on either side. These elements are: 1) Frame, 2) Crank, 3) Pedal & Foot, 4) Lower leg, 5) Upper leg, 6) Pelvis. On the frame's saddle, the pelvis is supposed to move rotation-wise only. The mobility of this closed chain results in a total of **3** degrees of freedom (DOF). The chain can be controlled and stabilized by **3** sets of antagonistic muscle groups, namely extensors and flexors of hip, knee and ankle joints respectively.

Practical analysis. In reality, "for a racing bike traveling fast, about 80 % the work the cyclist does will go in overcoming air resistance" (Woodford, 2016). Therefore road cyclists prefer a so-called aerodynamic position. However, this 'aero position' inevitably implies 15°-20° anterior tilt of the pelvis (Steve, 2016).

Material and methods. Based on Krupa (2013), an anterior pelvic tilt of 20° was simulated by means of osteology of the pelvis, starting from its neutral position. It results in a more posterior position of the *tuber ischiadicum*, and a more anterior position of the *spina iliaca anterior inferior.* Changes of lengths of muscles having their origins on these landmarks were simulated, using Krupa's pictures (2013).

Observations. In the optimal aerodynamic position, 20° anterior pelvic tilt results in a 7.5 % increase of the length of the hamstrings *(long head of m. biceps femoris* and *m. semimembranosus)* and a 6 % decrease of the length of the *m. rectus femoris*. These muscles are most active during pedal strokes (Schultz, 2015).

Results and Conclusion. The increase and decrease in length of these muscles in aero position may lead to respectively hamstrings passive insufficiency, and *m. rectus femoris* active insufficiency, as these muscles are now likely to shift away from their plateau region of optimal force (= 100 %) (Rassier et al., 1999).

Discussion. Such imminent muscle insufficiencies are reflected in "thigh injuries" such as "quadriceps and hamstring strains", as diagnosed in cyclists (Aleman and Meyers, 2010). Therefore, to restore optimal muscle force, Electro Vibro Stimulation (EVS) is strongly recommended (van Zwieten et al., 2007).

References

1. Huson A. (1985) The Closed Kinematic Chain as a Modelling Principle for the Locomotor System. In : Proceedings of the International Conference on Biomechanics and Clinical Kinesiology of Hand and Foot, K. Mothiram Patil and H. Srinivasan (Eds.), Indian Institute of Technology, Madras, India, 1-4.
2. Woodford C. (2016) The science of bicycles. Where does your energy go? URL: http://www.explainthatstuff.com/bicycles.html Accessed October 30, 2016.
3. Steve C. (s.d.) Perfect Bike Fit, Figure 2, Effects of hip rotation on lower back and aerodynamic positioning, Hips tilted forward approximately 15°. URL: http://www.tri-ecoach.com/art11.htm Accessed October 30, 2016.
4. Krupa K. (2013) Hamstring Length and Lower Back Pain. Pictures 2 & 3. URL: http://www.crossfitsoulmiami.com/wellness/5026 Accessed October 30, 2016.
5. Schultz M. (2015) The Primary Muscles Used for Cycling and How to Train Them. URL: http://home.trainingpeaks.com/blog/article/the-primary-muscles-used-for-cycling-and-how-to-train-them Accessed October 30, 2016.
6. Rassier D.E., Macintosh B.R., Herzog W. (1999) Length dependence of active force production in skeletal muscle. Journal of Applied Physiology, 86, 5, 1445-1457.
7. Aleman K.B., Meyers M.C. (2010) Mountain Biking Injuries in Children and Adolescents. Sports Medicine, 40, 1, 77-90.
8. van Zwieten K. J., Verhaegen I., Op ‘t Eijnde B., Zinkovsky A. V., Zubova I. A., Schmidt K. P., Lippens P. L. (2007) Electrovibrostimulation During the Training of Sportsmen, an Experimental Set-up. Journal of Vibroengineering, 9, 4, 50-54.