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BIOMECHANICAL ANALYSES OF ROAD CYCLING

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Introduction, theoretical approach. A biomechanical analysis of cycling can be realized theoretically with a closed kinematic chain [1], consisting of *elements* of the rider, and *elements* of the bicycle on either side (Figure 1). 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 [2]. The mobility of the chain is then calculated by applying Grübler's equation for planar linkages [3], resulting in a total of 3 degrees of freedom (DOF). In motion, this closed kinematic chain is thus controlled and stabilized by 3 sets of antagonistic muscle groups, namely extensors and flexors of hip, knee, and ankle respectively.

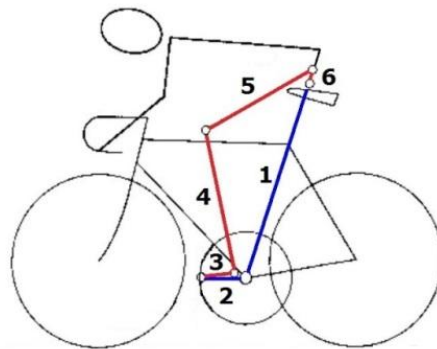


Figure 1. Bicycle and rider represented as a closed kinematic chain (after [2]).

Practical approach. A practical and more realistic biomechanical analysis however, reveals various other important features of road cycling, starting from the following. “For a racing bike traveling fast, about 80 percent of the work the cyclist does will go in overcoming air resistance” [4]. Therefore road cyclists do prefer to use a so-called

aerodynamic position (Figure 2). Their “aero position” inevitably implies an anterior tilt of 15°-20° of their pelvis (Figure 2, red line) [5].



Figure 2. Anterior pelvic tilt (red line) in aerodynamic position (after [5]).

Material and methods. Based on [6], an anterior pelvic tilt of 20° was simulated by means of osteology of the pelvis, starting from its neutral position. The results of it, a more posterior position of the *tuber ischiadicum*, and a more anterior position of *spinailiaca anterior inferior*, were taken into account. Resulting changes of lengths of those muscles that have their anatomical origins on these bony landmarks were then observed, using the pictures of [6]. These muscles are: the hamstrings and one part of the quadriceps femoris, namely *rectus femoris* muscle. This muscle and the hamstrings are most active during a pedal stroke [7].

Observational results. In the optimal aerodynamic position, 20° anterior pelvic tilt results in 7,5 % increase of the lengths of hamstrings *biceps femoris (long head)* and *semimembranosus*, and 6 % decrease of the length of quadriceps muscle part *rectus femoris*.

Results and Conclusion. The observed increases and decreases of lengths of these muscles in aero position may lead to respectively hamstrings passive insufficiency, and *rectus femoris* muscle active insufficiency, as these muscles are now likely to shift away from their plateau region of optimal force (= 100 %) [8].

Discussion. Such imminent muscle insufficiencies are reflected in “thigh injuries” “quadriceps and hamstring strains”, as described in cyclists [9]. Using a “gravity seat” possibly neutralizes some anterior pelvic tilt [10]. To restore optimal muscle force however, Electro Vibro Stimulation (EVS) is strongly recommended [11].

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