CHANGES IN BODY POSITION ON THE BIKE DURING SPRINT CYCLING: APPLICATIONS TO BIKE FITTING

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This study compared hip flexion angles during sprint cycling with those during sub maximal cycling performed using a range of handlebar positions. Eleven cyclists were assessed in two sessions. The first session involved determining handlebar positions that resulted in a range of maximum hip flexion angles. In the second session, cyclists performed 2 x 6-s sprints at the handlebar positions determined during the first session. Differences between predetermined hip flexion angles and the angles measured during the sprint ranged from <1-11°. Differences between measured hip angles were only observed when comparing the 70° with the 90-110°. During bike fitting, changes in handlebar positions that lead to hip angles of 90-110° may not lead to changes in performance due to acute changes in position of cyclists on the bicycle during the sprint.

KEYWORDS: cyclists, bike set up, joint kinematics.

INTRODUCTION: Bike fitting is a method that aims to optimise the configuration of the bicycle to the cyclist. The two major goals of bike fitting are to reduce the risk of overuse related injuries (Dettori & Norvell, 2006), and to enhance performance (Bini, Hume, & Croft, 2011). Most studies on the optimal configuration to improve cycling performance are based on endurance related tests, which limit the application of the current guidelines to road cyclists.

Bike fitting can be conducted by relating the dimensions of the bicycle with anthropometric measures of the cyclist (De Vey Mestdagh, 1998), or relating the bicycle configuration with target joint angles (Bini & Hume, 2016). This second approach targets pre-determined angles during stationary cycling, which provide a more consistent joint motion between cyclists (Bini & Hume, 2016). To accomplish this aim, real time or summarised measures of joint angles need to be measured to allow for changes in bicycle configuration to be undertaken. However, all current research in this area were applied to sub maximal cycling, which limits the transference of these methods to high intensity cycling disciplines such as BMX and track.

During sprints, maximum effort is produced in very short duration, which requires an optimum combination of muscles' force-length-velocity (Elmer, Barratt, Korff, & Martin, 2011). In order to achieve maximum velocity during the sprint, cyclists are usually advised to lower their upper body position (i.e. increase trunk flexion) with the purpose to reduce drag forces (García-López et al., 2008). However, finding the optimum upper body position that allows for minimum drag (large trunk flexion) and maximum power production [reduced trunk flexion – (García-López et al., 2008)] should involve testing various settings on the position of the handlebars (height and reach). This procedure then involves a real-time measurement of trunk/hip angle whilst cycling using various combinations of handlebars height and reach. Although this method is recommended, the use of sub maximal loads could lead to differences in joint angles in relation to those observed during the higher work rates (Bini, Senger, Lanferdini, & Lopes, 2012). However, it is unclear how hip angles change during sprints performed in pre-defined positions of the bicycle based on selected hip angles determined using sub maximal loads. Therefore, this study compared hip flexion angles taken during sprint cycling with those gathered from sub maximal cycling using a ranged of positions of the handlebars (changing height and reach).

METHODS: Eleven competitive cyclists (26.7 ± 13.1 years, 175 ± 10 cm, 74.1 ± 17.2 kg) with a minimum of two years of training in sprints volunteered for this study, which was approved by La Trobe University Ethics Committee (HEC 15-070). All cyclists trained on the road but were engaged in dedicated sprint training at the time of the study.

Participants attended two laboratorial sessions. The first session involved measurements of anthropometric data (body mass, standing height, arm span, shoulder and pelvis width, hip, knee and ankle heights to the floor and foot length). After that, 17 wireless motion tracking sensors were placed in pre-defined body segments as per instructions provided by the manufacturer for tracking full body motion (Xsens, Netherlands) followed by a static pose calibration. In parallel to anthropometric measures, bike dimensions (i.e. saddle vertical and horizontal positions and height and reach of the handlebars) were gathered to be replicated in the cycle ergometer (WattBike; model A, UK). Cyclists were then positioned on the ergometer and asked to pedal at ~100 W and 60 rpm whilst the angle between the upper leg and the pelvis, bilaterally, were assessed in real time. A range of pre-defined maximum hip flexion angles (70-110°; zero = upright position) were intended based on the minimum angle observed during the pedal stroke. This range led to more vertical positions of the trunk (smaller hip angles) and larger inclines of the trunk (greater hip angles). Whenever the assessed angle was visually close to the intended angle (±2°) in the motion analysis software (MVN Studio 4.4; Xsens, Netherlands), the height and reach of the handlebars were recorded. This process was repeated until we exhausted the range of settings from the cycle ergometer. After this process, cyclists performed three maximum 6-s sprints with fan resistance at 10 units and magnetic resistance configured to allow for 120-130 rpm of peak cadence (after the first sprint), as per proposed by Herbert et al. (2015). These sprints enabled participants to familiarise with the test and to determine required changes in the magnetic resistance to achieve the intended peak cadence. All sprints were performed seated and started in a static position with the preferred leg close to the 3 o'clock crank position.

In a second session, wireless sensors from the motion tracking system were fitted to the cyclists and the cycle ergometer adjusted to the dimensions required to achieve the pre-defined hip angles. They performed two 6-s sprints in each position determined in the first session, in random order, separated by 5-min of passive rest on the bike. Verbal encouragement was provided, and cyclists were instructed to perform maximally in all trials. Peak power output was recorded after each sprint from the head unit of the cycle ergometer.

Hip flexion angles were exported from the motion analysis software to determine the mean value for minimum hip angles during the 6-s sprints from both legs. A customised program in MATLAB (R2016b; MathWorks, USA) was developed to calculate the minimum hip angles. Data was then consolidated into a spreadsheet for comparison between the intended pre-defined vs. the true hip angle during the sprints. Paired samples t-tests and Cohen's effect sizes were calculated to assess difference in hip angles and peak power output across positions. Whenever $p < 0.05$ and Cohen's $d > 0.80$, substantial differences were considered for discussion. Confidence interval for the differences (95%CI) between the intended and the measured hip angles were computed for each position.

RESULTS: Due to limitations in range of motion for some cyclists, not all pre-defined angles were completed by all cyclists. Differences between the pre-defined hip angles and the angles measured during the sprint ranged from <1-11° (95%CI 3-9°; Table 1). Significant differences between measured hip angles were only observed when comparing the 70° with the 90-110° (no difference in relation to the 80°). A trend for significant difference between 70° and 80° was observed ($p = 0.07$ and $d = 0.84$). Peak power output was not significantly different between trials ($p = 0.17$-0.90, $d = 0.28$-0.74).

Table 1: Differences between intended hip angles and measured hip angles during the test and peak power output (PPO – in Watts per kg of body mass).

Intended Hip Angles (°)	Measured Hip Angle (°)	Difference (Mean ±SD°)	95%CI	PPO (W/kg)
70 (n = 5)	81 (9)	<1 ± 9	6	16 ± 3.6
80 (n = 9)	88 (8)	8 ± 6	3	15 ± 3.4
90 (n = 11)	92 (8)*	2 ± 7	3	15 ± 3.2
100 (n = 7)	93 (9)*	7 ± 8	5	14 ± 3.1
110 (n = 3)	96 (8)*	11 ± 11	9	14 ± 2.9

* indicates difference in relation to the 70°, when $p<0.05$ and Cohen's $d>0.80$ were observed.

DISCUSSION: The aim of this study was to assess whether cyclists would sustain hip angles taken during sub maximal cycling effort during 6-s sprints in various positions of the handlebars. Our study observed that, although changes of hip angles of 10° were enforced during the sub maximal trials, the angles during the sprints did not replicate those observed during sub maximal effort. This finding is very important because most bike fitting methods rely on measurements taken either statically or at sub maximal work rates (Bini & Hume, 2016), which in the case of sprint cycling, does not ensure similar outcomes. Peveler et al. (2012) observed that lower limb angles are sensitive to changes in work rate, which has not been supported by Bini et al. (2012). In addition, given these studies have undertaken graded exercise tests to exhaustion, the range of loads covered by sprints has not been assessed. Therefore, our findings provide evidence that translating measures taken during sub maximal work rates are not reliable for sprint cycling. Our findings also indicate that changes in bicycle configuration did not lead to changes in cycling performance, which suggest acute optimisations in muscle coordination to sustain power production.

During cycling, the central nervous system controls the muscles in order to maximise force production (Elmer et al., 2011). To accomplish that, cyclists tend to move on the bicycle, particularly when work rate is increased, to optimise their body position throughout the effort (Bini et al., 2012). This is another novel finding from the current study given no prior evidence has shown that cyclists continuously optimise their position and sustain a similar performance. This is clearly observed by the absence of differences between hip angles during most positions tested (apart from the 70°). In line with that, prior studies conducting changes of 10° in joint angles prior to cycling, did not observe differences in joint kinetics (Bini, Hume, & Kilding, 2014), which indicates that changes in bike configuration should be larger than the ones conducted in this study to allow for changes in performance.

Sprint cycling involves the balance between maximum power and minimum drag force (García-López et al., 2008). Although we did not assess drag forces, we are to expect that by opting for a lower position of the handlebars (i.e., hip angle closer to 110°) cyclists would be expected to achieve the intended balance of maximum power and minimum drag force. Therefore, our findings highlight that, even pedalling with a substantial hip flexion, cyclists may have changed their muscle force distribution to sustain power production. As potential changes, a reduction on the contribution from hip flexors (due to short length) and an increased contribution from hip extensors (due to longer lengths) could be expected. Further studies should be conducted given there is no data on this level of muscular acute adaptation in sprint cycling.

This study has some potential limitations. Our cyclists were not training exclusively for sprints, which could have resulted in various adaptations to different bicycle configurations. Their combined road and sprint training might have hindered adaptation to a larger hip flexion. Our range of changes in hip angles were limited, particularly at the extreme angles (70° and 110°), which reduced our sample size in these positions. Further studies are needed to assess more cyclists in order to determine if our preliminary finding will hold true in a larger cohort. Our method to determine the hip angle relies on changes in the position of the pelvis in relation to the upper legs. Therefore, increased trunk flexion could have occurred without being reported in this study. Further analysis of this data would shed light on whether upper body positions were largely changed at the various trials. Some cyclists (n = 5) were junior but trained and competing in sprints, which could have reduced their experience in performing sprints maximally. However, we believe that our familiarisation session provided sufficient practice for all cyclists before data was collected.

CONCLUSION: This study highlighted that hip joint kinematics determined during sub maximal cycling were not maintained during maximal sprints. We also observed that a wide range of different hip flexion angles, imposed by changes in height and reach of the handlebars, did not affect 6-s sprint cycling performance. Potentially, acute changes in body position on the bicycle by cyclists explain this result. Therefore, bike fitting should be load specific, particularly for sprint cyclists.

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