EFFECT OF DIFFERENT HANDLEBAR HAND POSITIONS ON FAST BRAKE LEVER REACHING MOVEMENTS IN CYCLING

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INTRODUCTION: The aim of the present study was to evaluate the effect of different kinds of handlebar hand positions on fast brake lever reaching movements. More specifically, it was investigated whether the use of clip-on handlebars significantly altered the time taken to reach brake levers compared to times obtained with traditional hand positions on the handlebar.

The underlying assumption motivating the study is that riding positions providing quick access to brake levers allow athletes to more easily manage the braking operation when forced to suddenly decrease bicycle speed or change direction to avoid an unexpected obstacle.

For this reason, an additional goal of this research was to estimate whether the time spent in reaching the brakes, regardless of the riding position, is a factor of great or minor importance in influencing the distance needed for a bicycle to be brought to a stop in an emergency.

METHODS AND PROCEDURES: *Subjects* Three high level road cyclists were the subjects of this study. Each athlete was tested while pedaling on his own racing bicycle mounted on a magnetic braked roller simulator. The bikes were equipped with a Cinelli Spinaci clip-on handlebar.

While pedaling, the athletes were asked to reach, as quickly as possible, the brake levers (as they should brake their bike in the shortest time possible) from the following starting pre-defined handlebar hand positions:

(1) on the lower ends of the handlebar bend (on the drops)
(2) on the lateral side of the handlebar bend
(3) on the upper lateral side (hands around the top of the brake lever mounts)
(4) the most comfortable top-bar position for each athlete
(5) on the middle section of the top handlebar bend with the hand spaced
(6) on the clip-on handlebar
(7) on the top of the handlebar bend with the hands close to the stem.

These positions were randomly varied from trial to trial with the limitation that each was used equally often for each subject. Further, the subjects performed the braking actions under the following trigger conditions: responding to a visual stimulus, to an acoustic stimulus, and free to choose when to start the movement. For each of the resulting 21 experimental conditions, data of 10 trials were acquired.

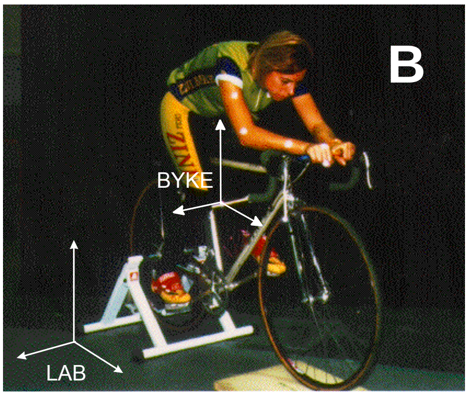
Equipment At a sampling rate of 100 Hz, the ELITE motion analysis system (Ferrigno and Pedotti, 1985) was used to collect the 3-D kinematic variables of the right upper limb segments with respect to the handlebar and right brake lever frame.

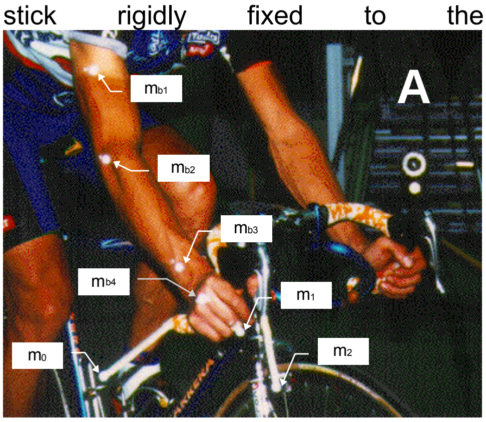
To this end, the configuration of the ELITE system was the following: two TV cameras paired off on the right side of the subject; the calibrated volume for the 3-D co-ordinates computing was 1.25 long, 1.25 high and 0.5 wide.

handlebar (m_0) and on a stick rigidly fixed to right brake lever (m_2).
Figure 1. A) Marker's positioning, B) Representation of the laboratory and local bicycle reference system

To verify the measurement accuracy of the system, a test was carried out before

Five small retroreflective markers (8 mm in diameter) were glued on the subject's skin in correspondence of the following anatomical repere points (Fig. 1 A): $\mathbf{m_{b1}}$ the lateral side of the arm at deltoid insertion, $\mathbf{m_{b2}}$ lateral ephicondyle, $\mathbf{m_{b3}}$ distal end of the radio-ulnar joint, $\mathbf{m_{b4}}$ distal end of the 3rd metacarpal, $\mathbf{m_1}$ distal end of the 3rd phalanx. Two additional markers were located on a stick rigidly fixed to the





each experimental session. The mean differences between the measured and actual distance of two markers fixed on the rigid bar moved along the whole field of view was within 0.4 mm, in agreement with the values given by the manufacturer.

Data elaboration Data processing included a 2-D tracking of the markers detected by each TV camera and a 3-D reconstruction. The filtering of the 3-D markers co-ordinates and the computing of their derivatives were performed by using the algorithms developed by D'Amico and Ferrigno (1990). To account for the bicycle movements, the measured co-ordinates were then referred by trigonometry to a reference system fixed to the bike handlebar (Figure 1 B).

The time the rider takes to reach the right brake lever was defined as the time from the first detectable movement of the marker $\mathbf{m_1}$ until the first occurrence of the $\mathbf{m_2}$ marker movement. In the trials triggered by an external stimulus the pre-motor time was also measured as the time from the signal presentation until marker $\mathbf{m_1}$ moves.

Statistical analysis The effect of the different kinds of handlebar hand position on brake lever reaching times was analyzed with one-way ANOVA. The existence of significant between-condition differences was then tested using the Newman Keuls post hoc test. To determine whether the brake lever access time with the clip-on handlebar position was different from each of the other conditions, a Student's ttest for paired data was also performed. All comparisons were considered significant at an alpha level of P < 0.05.

RESULTS AND DISCUSSION: _Reaching-times_ Figure 2 illustrates, as a function of the different riding positions, the mean and standard deviation brake lever reaching-times (in ms) produced by all the subjects in the different experimental variants. Data were obtained by analyzing all the 630 trials acquired.

The values ranged from 147 ms of posture (3) (hands on the upper lateral side of the bend, close to the top of the brake lever mounts) to the 276 ms of position (7) (hands on the top of the handlebar bend, close to the stem), with a largest difference of 129 ms. According to the found mean duration values (always less than 300 ms) the examined movement could be classified as short, pre-programmed motor responses, controlled via an open-loop process, without any possibility to change the movement pattern once started.

As expected, positions with hands placed around the brake levers were characterized by slightly lower brake access times compared to the others. In concert with some previous studies on human movement, these results indicate that the movement time heavily relies on the spatial distance from the starting to the final position, rather than on many other factors such as movement amplitude and trajectory, number of joints involved, and selected individual neuromuscular characteristics.

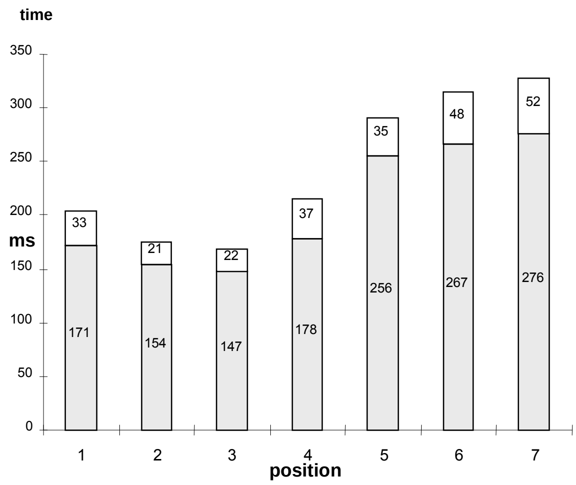


Figure 2. *Mean and standard deviation brake levers reaching-times produced by all the subjects as a function of the different riding positions (630 trials)*

The above findings allow one to split the examined positions into two groups according to the movement rate: one including positions with movement times less than 200 ms (1), (2), (3) and (4) and another including positions with movement times longer than 200 ms.

Examining the latter, no differences were found between the position with the hands on the clip-on handlebar and position (5) (hands on the middle section of the top handlebar bend) and (7) (hands on the top of the handlebar bend in proximity to the stem). The largest differences between the clip-on handlebar position and the posture with the quickest brake access time was 120 ms, resulting in a 2 m travelling distance at 60 Km/h.

Estimate of the effects of the time taken to reach brake levers on the total braking distance. One of the goals of this study was to evaluate whether the time spent in reaching the brakes, regardless of the riding position, is a factor of great or minor importance in influencing the distance necessary for a bicycle to be brought to a stop in an emergency.

To this end, the following simple calculations were performed: first, the bicycle travel distances were computed for three typical riding speeds (36, 48 e 60 Km/h) during the time it took to reach the brake levers. The results, obtained from the time values shown in Figure 2, revealed a maximum difference among the analyzed positions of 1.3, 1.7, and 2.1 m at 36, 48, and 60 Km/h respectively.

Then, these extreme values were related to the total braking distance. Assuming a maximum braking deceleration of 6 m/s^2 (hard braking without causing loss of control), the distance the bike travels before coming to rest from the time when the athlete applies the brakes, was determined for the three chosen speeds.

Finally, the distance the bike will travel during a pre-motor time of about 180 ms (typical value in laboratory tasks) and a brake lever reaching-time of 260 ms was added. In doing so, the total braking distance from the instant the rider perceives the danger was estimated. The values were found to be 13, 21, and 30 m at 36, 48 and 60 Km/h. These results would indicate that the maximum riding posture-induced differences account for a percentage of 10, 8, and 7% of the total braking distance, assuming a bike speed of 36, 48 and 60 Km/h, respectively.

However, it should be noted that the pre-motor time value used for the calculation (180 ms) refers to a typical laboratory task with the subject knowing that a trigger signal it is going to be presented. In real world situations, with the subject required to react to an unforeseeable stimulus, longer pre-motor times up to 600 ms were found. Given the above, the calculated percentage values may be even overestimated.

CONCLUSIONS: In summary, the results presented here indicate that:

- In each of the examined experimental conditions, the time the athlete takes to reach the brake levers (lower than 300 ms) represents a small fraction of the total time necessary to stop a bicycle after an emergency signal was perceived:
- Hand positions slightly affect the access time to the brake levers. However, this is true only in the comparison positions where the hands are placed very close to the brake lever mounts. At any rate, it was demonstrated that even in the worst case the found posture-induced differences account for less than 10% of total distance the bike travels before coming to rest:
- Riding with the hands placed on the clip-on handlebar leads to brake lever reaching-times as high as those measured adopting other traditional positions with the hands placed on the handlebar.

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