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Experimental assessment of the effect of cyclist's posture on comfort during time-trial events on road cycling

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Abstract:

During cycling, road irregularities are transmitted to the rider through the bicycle in terms of vibrations. The contact areas between the bicycle and the cyclist are the buttocks, hands, and feet, and in the cases in which aerobars are used, the elbows. The relevance of the quantification of vibrations transmitted to cyclists lies in their relationship with comfort (Doria, 2020) and potential health risks. The effect of vibrations on human activities depends on their magnitudes and the time of exposure. For this reason, in this study, the magnitudes of vibrations transmitted to cyclists while riding in different postures were quantified and the time of exposure to such vibrations during cycling was analyzed. This work presents the results obtained from implementing a pilot methodology to assess the effect of the change of cyclists' posture on the vibrations' transmission. The posture variation was performed by modifying the aerobars height considering a time-trial cycling scenario. The magnitudes of vibrations transmitted through the seat post and steering tube were quantified in terms of vibration total values. In addition, an analysis of the implications of the time of exposure to vibrations in cycling was performed based on thresholds of exposure increasing health risks.

Five recreational cyclists voluntarily participated in the tests after signing an informed consent form (mass: 73.8 ± 11.8 kg, height: 1.75 ± 0.06 m, age: 35 ± 7 years). The riders used their own bicycles and standard cycling clothes. The tests were performed on aerobars postures varying the height of the elbow pads using spacers on the steering tube or the aerobars support. The height was set to the maximum (ABhigh) and minimum (ABlow) allowed by each bicycle settings.



Figure 1. Left, set up for the vibrations' transmission measurement. Right, acceleration orientations analyzed in the study.

The vibrations were measured during outdoor tests while the riders pedaled on a testing route at a constant speed. The accelerations along three directions were registered on the seat post and steering tube with accelerometers. The tests consisted of traveling three times at a constant speed of 25 km/h on a 400 m straight route with smooth asphalt. Wireless triaxial accelerometers with a sampling frequency of 5000 Hz (SlamStick LOG-0002-025G-PC, MIDE, USA) were placed on the bicycles using clamp supports, as presented in Fig 1. A GPS (Forerunner 910, GARMIN, USA) and a speed sensor (Speed sensor 2, GARMIN, USA) were used to register and display the speed to the rider in real time.

The vibrations were computed in terms of vibration total values (a_v) combining the rms accelerations on three orthogonal coordinates and considering the human sensitivity according to ISO2631 (ISO, 1997) for the seat post and ISO5349 (ISO, 2001) for the steering tube. It is worth highlighting that a_v and comfort are inversely related. The thresholds of exposure increasing health risks were assessed considering the curves of health guidance caution zones for whole-body vibration presented in ISO 2631 and the threshold for an increased probability of presenting the hand-arm vibration syndrome presented in ISO 5349. Considering the equivalency between vibration exposures, it is possible to estimate acceptable values of exposure to vibrations (a_a) for given exposure times (t_e) for the accelerations on the seat post and stem, as expressed in Equations (1) and (2), respectively.

$$a_{a,seatpost} = 1.2\sqrt{4/t_e} \quad (1)$$

$$a_{a,steeringtube} = 2\sqrt{8/t_e} \quad (2)$$

The magnitudes of vibrations transmitted to the cyclists through the seat post and steering tube are graphically presented in Figure 2. A one-way ANOVA was performed using a significance level of 0.05 to verify the differences in the a_v between postures. Regarding the seat post, it was obtained that for all the riders, the vibrations increased when changing from ABhigh to ABlow (between 3% and 12%). Nevertheless, only for cyclists 2 and 3, the difference was statistically significant. Regarding the steering tube, a significant difference was found only for cyclist 5, whose acceleration index decreased by 21% when changing from ABhigh to ABlow. The results show that the magnitude of the difference in the a_v of the seat post and the steering tube between the postures changes for each cyclist. The results indicate that for some cyclists, ABlow is less comfortable in the saddle and more comfortable in the steering tube than ABhigh.

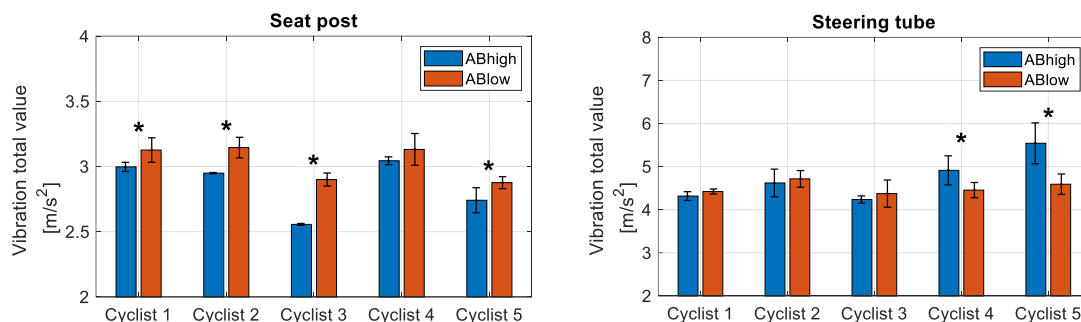


Figure 2. Vibration total values. Left, results for the seat post. Right, results for the steering tube (Asterisks used for pointing out statistically significant differences between postures).

By analyzing the acceleration magnitude ranges registered in this study in the seat post and the stem with respect to the acceptable values of exposure to vibrations, it was observed that the exposure duration to enter a zone of health caution varies between 30 minutes and 2 hours. These time ranges are commonly exceeded in cycling during training and competition, reflecting potential adverse effects on the riders' health due to the prolonged and continuous interaction with the bicycle.

In conclusion, the implementation of an outdoor methodology for assessing the vibrations transmitted to the rider while cycling permitted identifying differences in the vibrations due to changes in the riders' posture. It was observed that for some riders reducing the height of aerobars improved the comfort in the elbows while worsening the comfort on the buttocks. It was also concluded that the exposure to vibrations during cycling should be evaluated in reference to the duration of the riding sessions to reduce possible scenarios of health risk. It is expected to perform the experimental assessment of the effect of cyclist's posture on comfort for a larger group of cyclists to confirm the findings.

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