Vibrational analysis of a flexible bicycle stem during indoor in-vivo cycling on a two rollers servohydraulic test bench

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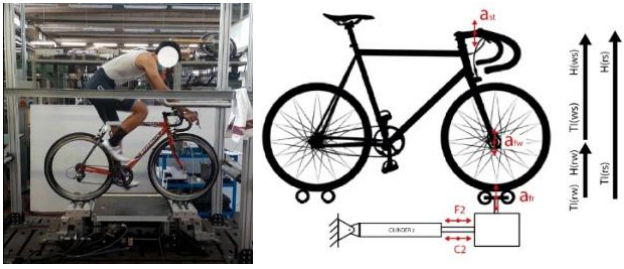
Introduction. Comfort is an important parameter correlated to bicycle usability and depends deeply on vibrations and human perception. Most of the vibrations are generated by the interaction between road and wheels and sensed at hands and seat [1-2]. Different approaches were used to evaluate the in-vivo behaviour of different bycicle postures and components, including vibrational excitation applied to the wheels [2-3]. The current work presents results obtained from a full scale roller bench test designed to make vibration analysis on bike and components, on a flexible stem designed to improve the riding comfort [3].
External vibrations were applied to both wheels using a two-rollers servo-hydraulic test bench with a random load function generator corresponding to road types defined by the ISO 8608: 2016 [3].
Methods. A specific flexible stem (Shockstop (Redshift Sports,Philadelphia,USA)), designed to reduce accelerations transmitted to the hands by selectable elastomeric shock-absorbing inserts (SOFT, MEDIUM, HARD), was compared to a standard rigid stem (Deda zero 100 Alluminum(Deda Elementi,Campagnola Cremasca,ITA). Three road profiles with increasing harshness (A= Airport runways and super highways; B= Normal pavements; C= Unpaved and damaged roads, ISO 8608: 2016) were applied to the cyclist in two postures (Posture1-Hands on brake hoods, Posture2-Hands on handlebar drops). Fig.1 (a)



(a) (b)

Fig. 1: (a) Tester pedaling during test session on test bench, Posture 1 , (b) Main quantities.

The dependent variables recorded were accelerations $a_{(fw,fr,st)}$ (fw=front wheel, fr=front rollers, st=stem) and transfer functions H(rw, ws, rs) where subscript indicate “from-to” vibration transmission (r=rollers, w=wheel hub, s=stem)Fig. 1(b)

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Comfort was evaluated by a Transmission index *TI* between rollers and stem based on root mean square of the accelerations of stem and front rolls(a_{st}^{RMS} and a_{fr}^{RMS}) and a Comfort Index, *CI*, wich expresses the human body sensibility in seated position along the vertical Z-axis for the human body trunk (from ISO 2631-1):

$$TI(rs) = \frac{a_{st}^{RMS}}{a_{fr}^{RMS}} \quad (1) \qquad CI_{12\text{-}16} = \frac{1}{\int_{12}^{16} Hrs\ df} \quad (2)$$

Higher CI idicates higher confort; Higher TI indicates higher acceleration.

Results. Table 1 reports the Comfort index and Transmission index percent difference with respect to the rigid stem (Red cells represent lower performance). Based on CI the flexible stems improved comfort in both postures and stem hardness with lower road harshness but showed unfavorable results in Posture 1 tested on Road C. The transmission index gived opposite results than the CI in Posture 1, but it showed better agreement in posture 2.

Table 1:*Comparison of CI e TI difference % respect rigid stem(green:improved,red:worsened)*

		Road A		Road B		Road C	
		ΔCI%	ΔTI%	ΔCI%	ΔTI%	ΔCI%	ΔTI%
Posture1	SOFT	6,04	82,63	0,50	38,33	-2,66	-12,95
	MEDIUM	0,61	86,15	1,78	40,79	-3,52	-9,96
	HARD	1,05	132,47	2,81	12,47	-2,10	-10,48
Posture2	SOFT	0,12	0,71	3,35	-15,37	0,73	25,84
	MEDIUM	7,76	-5,97	3,06	-16,47	0,96	-24,80
	HARD	2,97	-6,43	4,36	-7,30	-0,08	5,22

Conclusions. The study showed the suitability of the rollers test bench for the stationary analysis of comfort related component in bicycle. However the significance of the two parameters CI and TI need future research with a larger number of subjects and their subjective evaluation of perceived comfort.

References

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The research was conducted in accordance with the principles embodied in the Declaration of Helsinki. Participants gave consent to participate and for the publicaion of the study.

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