Good Vibrations? An investigation examining the effects of speed, tyre pressure and Wheel choice on whole-body vibration during road cycling

Will Dixon[1], Timothy Holsgrove[1]*

[1]Department of Engineering, Faculty of Environment, Science and Economy, University of Exeter, Harrison Building, Streatham Campus, North Park Road, Exeter, United Kingdom, EX4 4QF
*Corresponding author – t.holsgrove@exeter.ac.uk

Abstract: Whole-body vibration (WBV) can be detrimental to health leading to numerous musculoskeletal disorders among other issues. The aim of this study was to investigate the effects that speed, tyre pressure and wheel choice had on WBV while road cycling, with added analysis provided by the implementation of a power spectral density (PSD). WBV exposure can be quantified using two values; the average exposure over an eight-hour day (A(8)) and the fourth-power vibration dose value (VDV), which are both outlined in ISO-2631. The European Union Vibration Directive has set an exposure action value (EAV) and exposure limit value (ELV) based on these values. The EAV means that the WBV is at a level where an employer should take action to reduce it ($A(8) = 0.5\ ms^{-2}\ RMS$, $VDV = 9.1\ ms^{-1.75}$), while the ELV is a value which should not be exceeded ($A(8) = 1.15\ ms^{-2}\ RMS$, $VDV = 21\ ms^{-1.75}$) as it can cause significant harm. The study was performed around a 1-kilometre loop on varying road surface by one participant. The wheelsets used were provided by Hunt Wheels (Hunt Limitless 48 and Hunt Aero Wide 34); each of these were tested at speeds of 20,30, and 40 kilometres per hour (kph), each at a pressure of 60,70,80 and 90 pounds per square inch (psi). Each combination was repeated 7 times. The bike was fitted with three accelerometers to record the vibration; positioned at rear hub, saddle and lumbar to measure WBV. The recorded data was then processed using a custom MATLAB script to calculate A(8) and VDV values. Additionally, a PSD of the vibration was plotted using Welch's Method which the max power, the frequency where the maximum occurred, and the absolute power were extracted. The VDV occupational limit was exceeded at all sensor locations in all the runs. At the rear hub the VDV value increased by 35%, 55%, and 61% for each speed respectively which meant that the ELV was exceeded in some circumstances. Both tyre pressure ($p>0.075$) and changing wheelsets ($p > 0.793$) had no significant effect on reducing the value at the rear hub. The A(8) limit value was not passed and the time to reach it was over 3 hours at 40 kph. The max power and absolute power taken from the PSD both increased with speed by 50% from 20-30 kph and 100% from 30-40 kph. with the wheelset having no significant effect ($p>0.108$), however pressure did have significant effect, but only between 60 psi and higher pressures at lower speeds. The frequency at which the max power occurred at the lumbar was between 2.77-5.48 Hz which aligns with the destructive frequency of the lower back. WBV while cycling surpasses the occupational limits and changing speed, tyre pressure and wheelsets has no effect on reducing it to safe levels. Further research into products advertised to reduce vibration while cycling would be beneficial to the cycling community.

Keywords: whole-body vibration; hand-arm vibration; cycling; tyre pressure; velocity; ISO-2631