Vibration Characterization of Strollers and Cargo Bicycles for Transporting Infants

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Summary

Infants are transported in strollers and baby seats in cargo bicycles, but there is little existing knowledge for assessing health and comfort effects due to vibrations during travel. To improve this, we measure the vertical acceleration of these vehicles with dummy infants over five different road surfaces at typical travel speeds. Using the whole-body vibration ISO 2631 standard, we show that rough road surfaces, amplified by travel speed, may have health risks for travel durations as low as 10 to 30 min. Tested stroller designs from 50 years ago significantly reduce vibrations indicating the value of good suspension. Cargo bicycles ridden at the maximum e-bike speed over paver bricks cause accelerations that should be avoided. Research is needed to develop direct connections to health and comfort, designers need to incorporate better suspension for infants, and new standards are needed for infant transport testing and evaluation.

Introduction

When a baby is born, it must be either carried or transported in a suitable means of wheeled transport. All means of transport cause vibration, which is transferred to the seated or lying infant. We investigate the vibrations that are experienced both in cargo bicycles and strollers to evaluate potential health risks and discomfort. To do this, we equipped five strollers and two cargo bicycles with inertial measurement units and conducted 93 experiment scenarios on different road surfaces and travel speeds, using dummies representing the mass of 0, 3, and 9 months old infants. We present results in the time and frequency domains, which allows comparing accelerations at the seat interface for whole-body vibration assessment, as recommended by ISO 2631-1 [1]. We report on the influence of different variables on vibration, such as type of vehicle, baby seat, traveling speed, dummy mass, and road surface to support our recommendations to users, designers, and future researchers.

Methods

We equipped the seat of five strollers (three modern and two vintage) and two seats mounted in two cargo bicycles (two-wheeler bicycle and tadpole tricycle) with accelerometers sampling at 910 Hz with a range of ± 16 g. We filled dummies with sand matching the mass of average 0, 3, and 9 month infants. For strollers, we pushed at 5 $\mathrm{km\,h^{-1}}$ over five surfaces: tarmac, paver bricks, sidewalk pavers, sidewalk slabs, and cobblestones. For cargo bicycles, we road over tarmac and paver bricks at speeds from 12 to 25 $\mathrm{km\,h^{-1}}$. Both vehicles were also subjected to shock.

We processed the vertical acceleration for 220 scenario repetitions with a 25 s average duration using recommended methods in ISO 2631-1. Signals were low-pass filtered at 120 Hz, whole-body vibration sensitivity weightings applied, and the root mean square (RMS) of the weighted amplitude spectra were calculated for each repetition. We compared vehicle-seat combination, road surface, and speed by fitting two statistical regression models to the data and compared vehicle-seat combinations via a post hoc Tukey comparison.

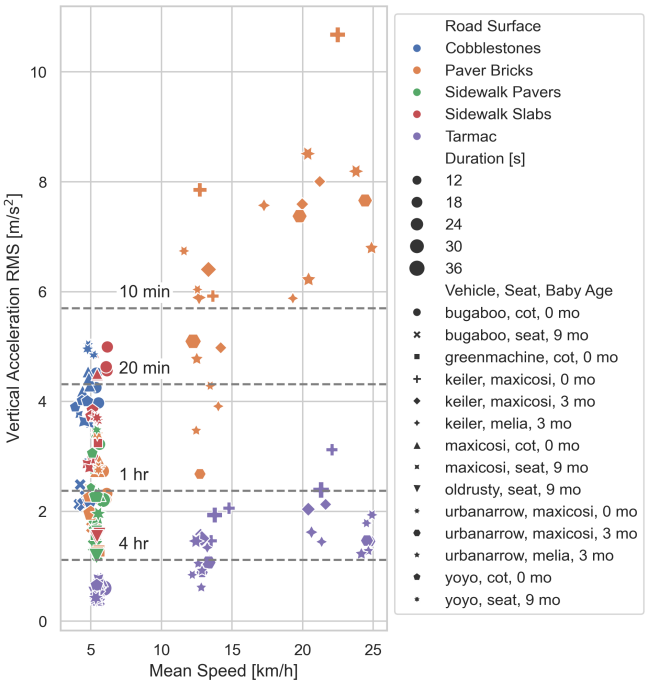

Figure 1: ISO-weighted RMS vertical acceleration versus speed. Markers at 5 $\mathrm{km\,h^{-1}}$ are strollers and the rest are cargo bicycles.

Results

Figure 1 shows the mean ISO-weighted RMS for each scenario compared to the limit of the ISO 2631-1 health caution zone for the specified duration of daily exposure for adults. Vibrations in strollers exceed the health caution limits of 20 minutes when pushed over cobblestones and sidewalk slabs. Only when pushing over tarmac does stroller vibration fall below the 4 h limit. Cargo bicycles ridden above 12 $\mathrm{km\,h^{-1}}$ on paver bricks cause vibration above the 20 min limit and over tarmac vibration can exceed the 4 h limit.

Conclusions

ISO 2631-1 advises caution when using it for situations other than 4 to 8 h daily vibration exposure of seated adults. With this caution in mind, we still recommend high roughness surfaces be avoided for stroller and cargo bicycle infant transport. For cargo bicycles, we recommend slowing to 12 $\mathrm{km\,h^{-1}}$ when riding over paver bricks and limiting the duration. We will close with discussion on how the current standards and research are insufficient for high certainty of vibration effects to infants and what should be done about it.

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References

[1] *ISO 2631-1* Intl. Org. for Standardization (1997)