Effects of (un)predictable whole body vibrations on visual performance

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Introduction

Over recent years, it has repeatedly been shown that optimal gaze strategies enhance motor control (e.g., Foulsham, 2015). However, little is known, whether, vice versa, visual performance can be improved by optimized motor control. Consequently, in two studies, we investigated visual performance as a function of motor control strategies and task parameters, respectively.

Study I: Variation of vibration frequencies and standardized postures

In Experiment 1, 72 participants were tested on visual acuity (Landolt) and contrast sensitivity (Grating), while standing in two different postures (upright vs. squat, see Figure 1) on a ZEPTOR-platform that vibrated at four different frequencies (0, 4, 8, 12 Hz). After each test, perceived exertion (Borg) was assessed.

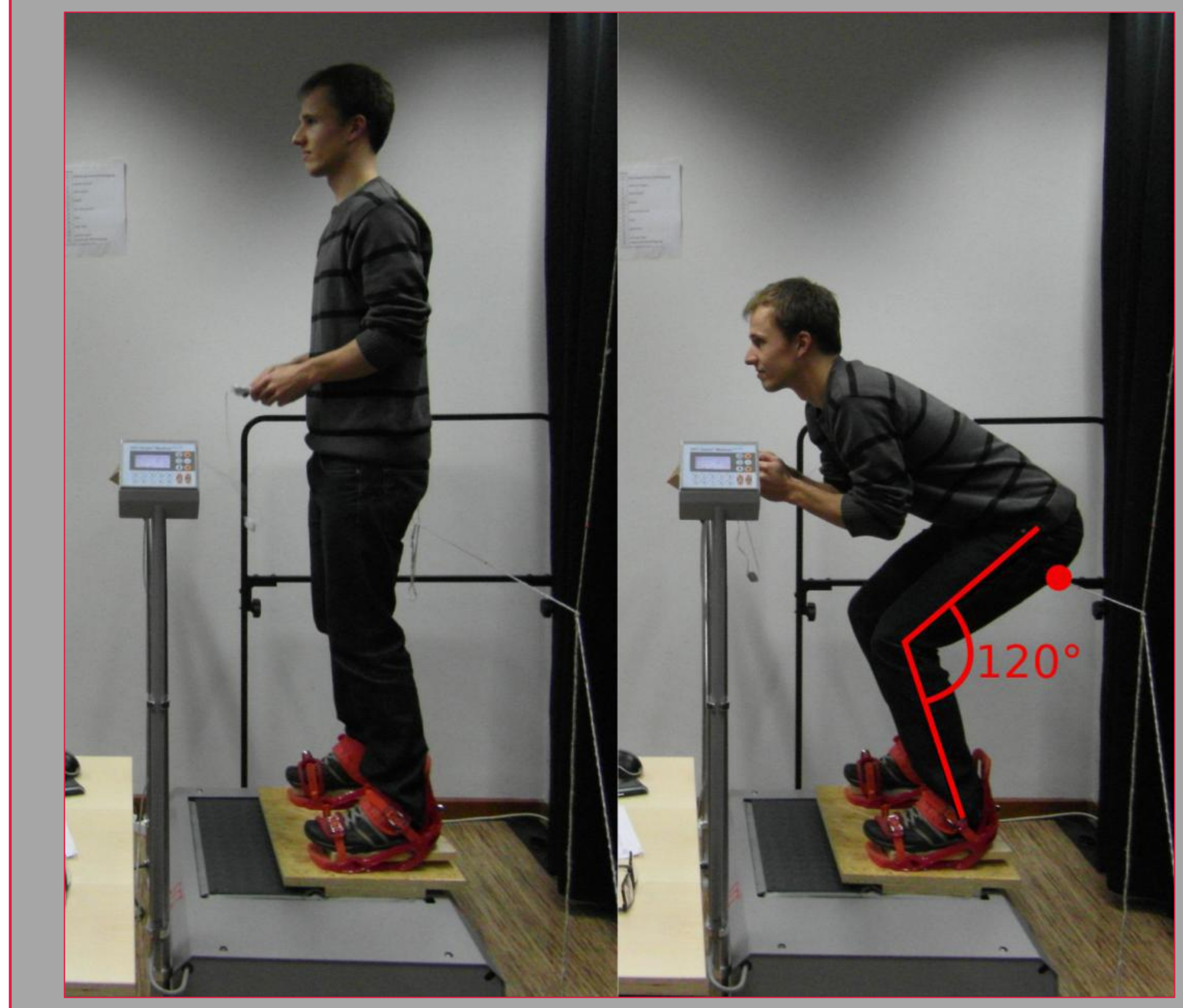

Fig.1. Standardized postures (upright, squat) for the assessment of visual performance.

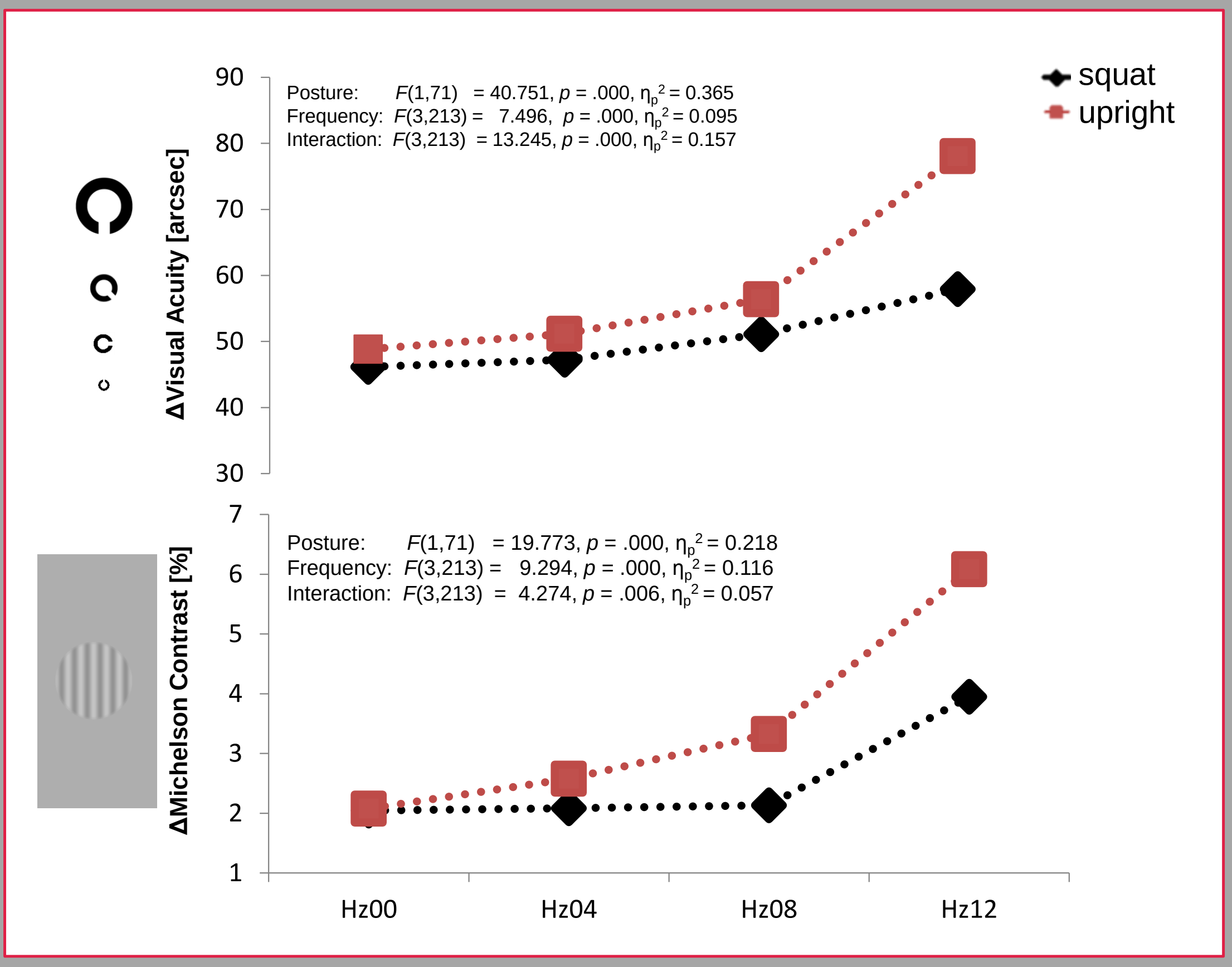

Fig.2. Visual performance drops for visual acuity (top) and contrast sensitivity (bottom).

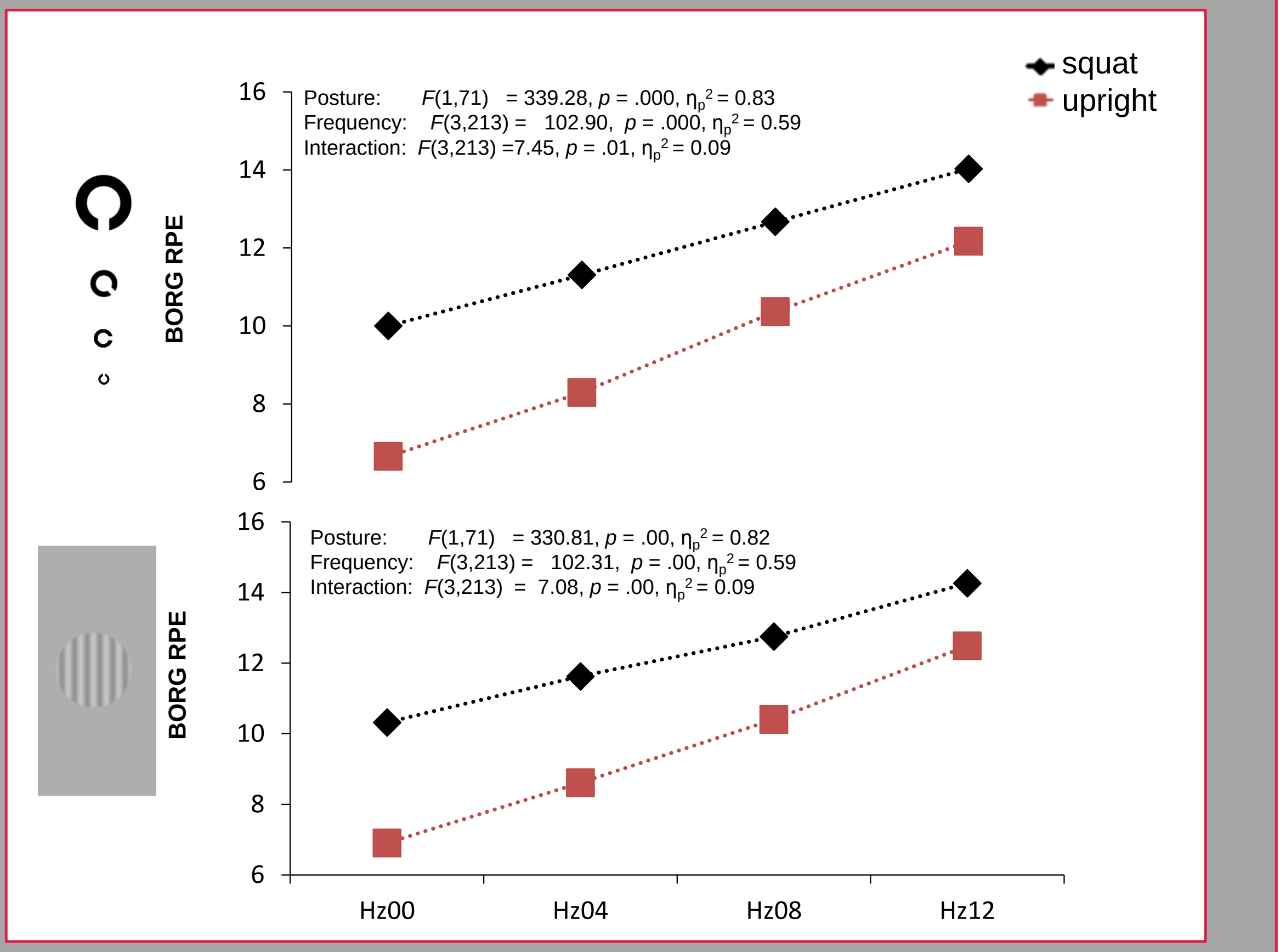

Fig.3. Perceived exertion ratings (BORG) for visual acuity (top) and contrast sensitivity (bottom).

Significant interactions were revealed for both tests, Landolt: *F*(3,213)=13.25, *p*<.01, η_p^2=.16, Grating: *F*(3,213)=4.27, *p*<.01, η_p^2 =.06, elucidating a larger loss of acuity/contrast sensitivity with increasing frequencies for the upright compared with the squat posture (Figure 2). For perceived exertion, however, a diametrical interaction for frequency was found for acuity, *F*(3,213)=7.45, *p*<.01, η_p^2 =.09, and contrast sensitivity, *F*(3,213)=7.08, *p*<.01, η_p^2 =.09, substantiating that the impaired visual performance cannot be attributed to exertion (Figure 3). Consequently, the squat posture could permit better head and, hence, gaze stabilization.

Study II: Lower Frequencies, higher amplitudes, self-imposed posture and kinematic measures

In Experiment 2, 64 participants performed the same tests while standing in a self-imposed squat position on a ski-simulator, which vibrated with two different frequencies (2.4, 3.6 Hz) and amplitudes (50, 100 mm) in a predictable or unpredictable manner (Figure 4). Control strategies were identified by tracking segmental motion, which allows to calculate eye-ball center positions and to derive damping characteristics (e.g. transmission factors).

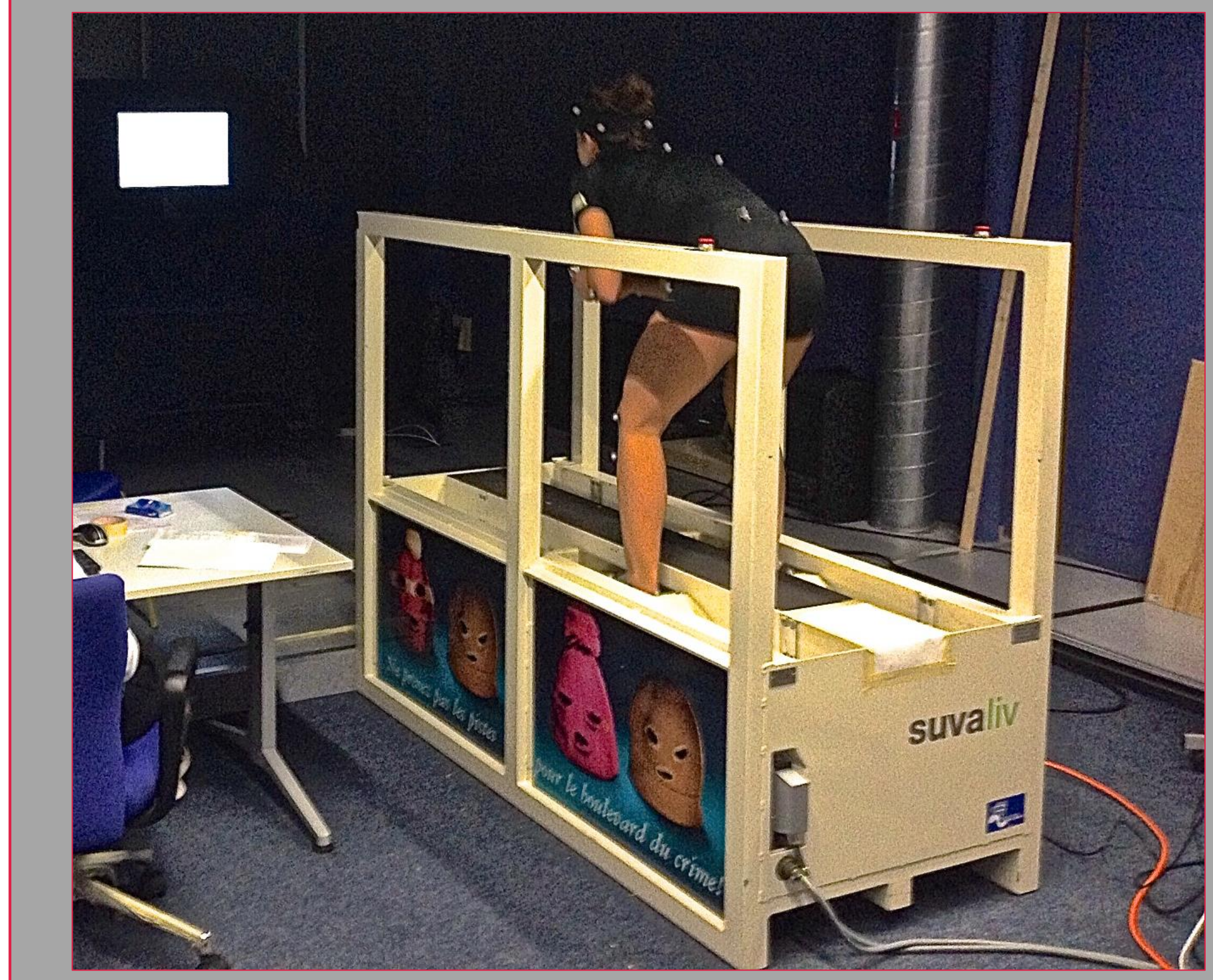

Fig.4. Participant in self-imposed posture on a ski-simulator vibrating predictably or unpredictably.

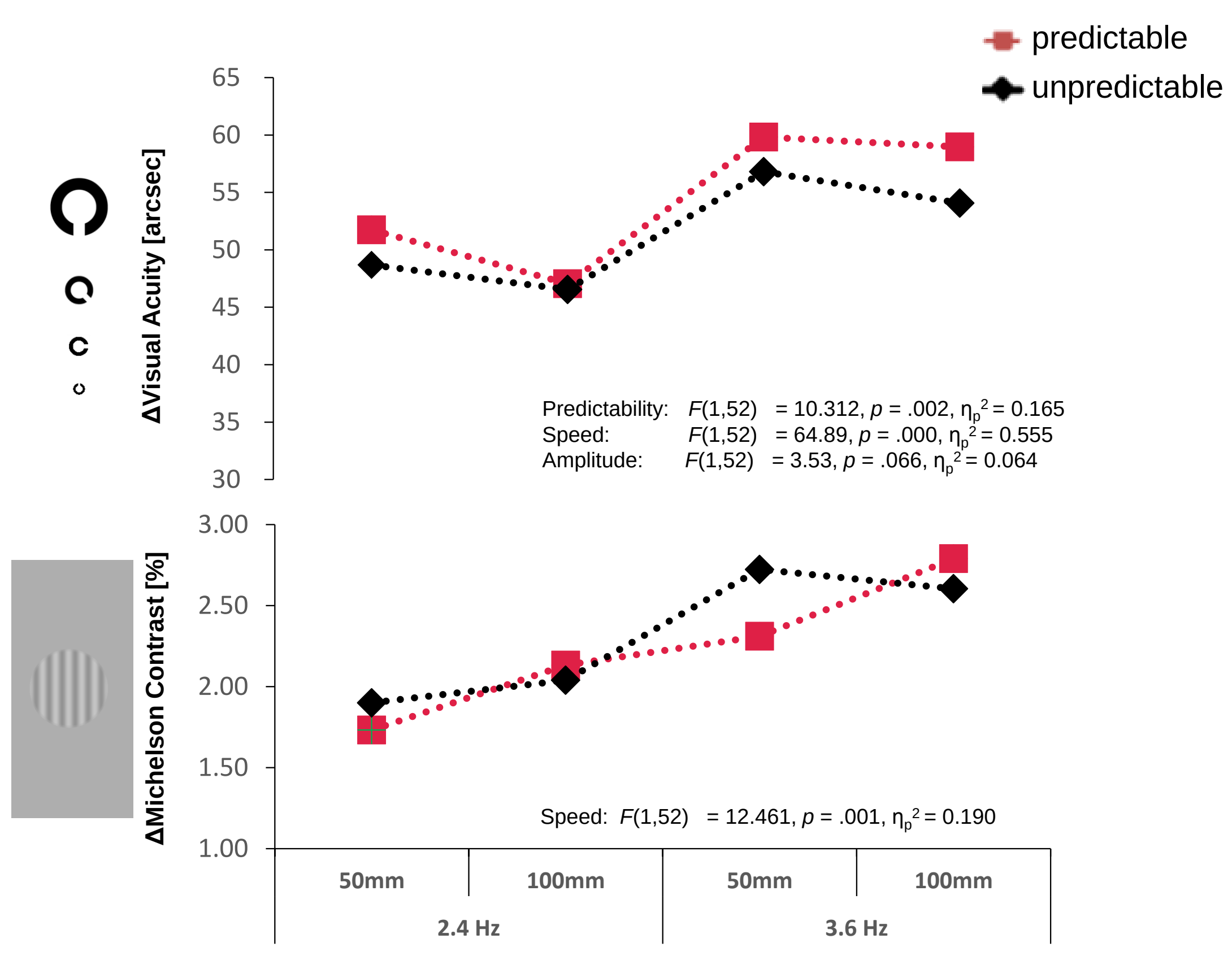

Fig.5. Visual performance drops for visual acuity (top) and contrast sensitivity (bottom).

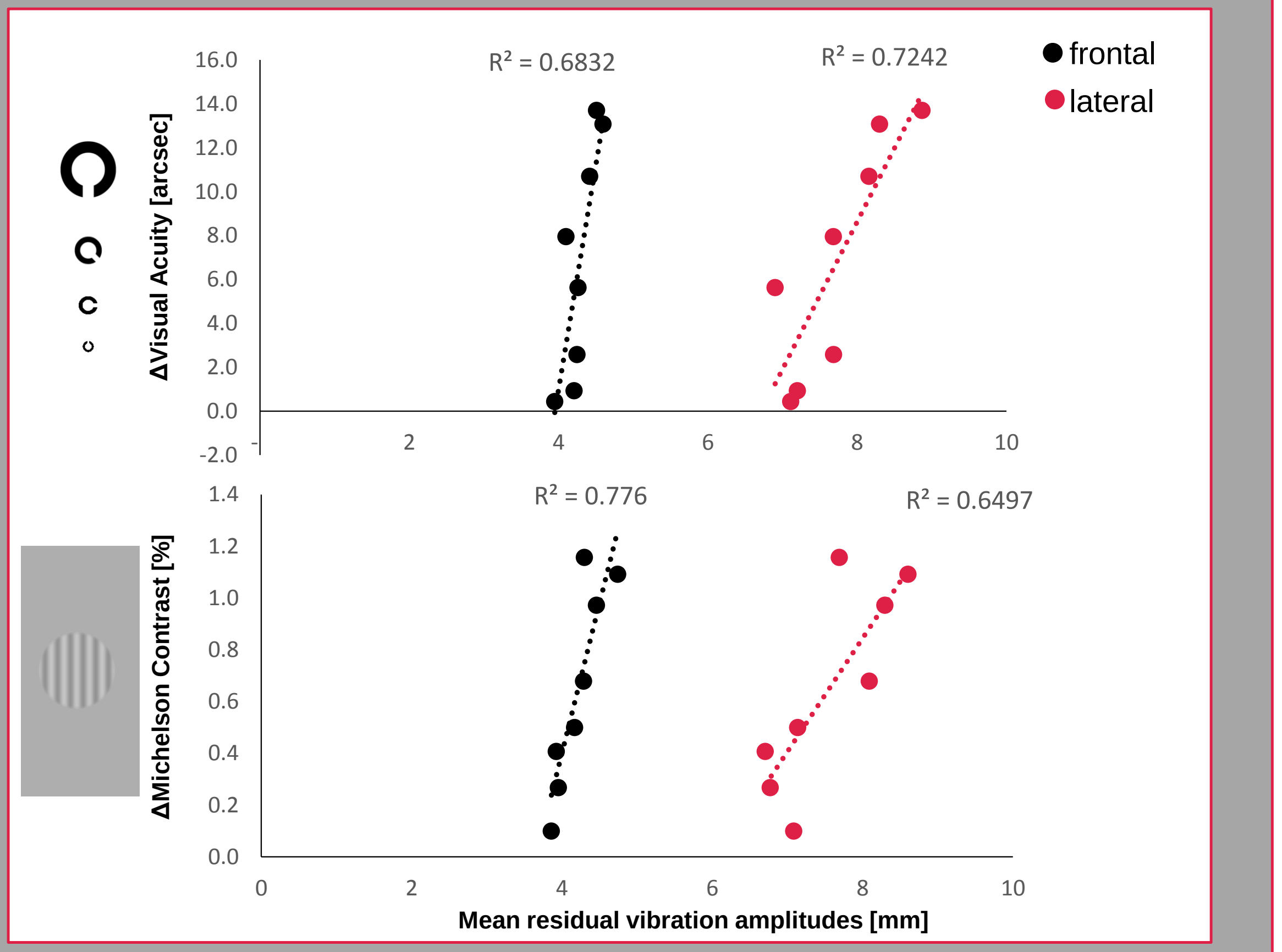

Fig.6. Mean residual horizontal vibration amplitudes of the eye-ball center highly correlate with the visual performance drops for visual acuity (top) and contrast sensitivity (bottom).

Considerable main effects were found for frequency, all *F's*(1,52)>10.31, all *p's*<.01, all η_p^2*'s*>.16, as well as, in the acuity test, for predictability, *F*(1,52)=10.31, *p*<.01, η_p^2 =.17, and by tendency for amplitude, *F*(1,52)=3.53, *p*=.06, η_p^2 =.06 (Figure 5). The high correlations between the horizontal eye-ball translations and the visual performance drops (Figure 6) as well as a significant correlation between the damping amplitude in the knee joint and the performance drop in visual acuity, r=-.97, *p*<.001, again point towards the importance of motor control strategies to maintain optimal visual performance.

General Discussion

The presented experiments indicate that visual performance can be sustained by optimal motor control strategies for the task at hand. As this is the case for unpredictable task settings as well, strategies that control joint stiffness, e.g. within the framework of impedance control (e.g. Franklin, Osu, Burdet, Kawato, & Milner, 2003), seem to be of particular importance. Currently, further experiments including joint stiffness measurements are undertaken with novice and expert skiers with the intent to reveal differences in impedance control.

Literature

Foulsham, T. (2015). Eye movements and their functions in everyday tasks. *Eye*, *29*, 196-199.
Franklin, D.W., Osu, R., Burdet, E., Kawato, M., & Milner, T.E. (2003). Adaptation to stable and unstable dynamics achieved by combined impedance control and inverse dynamics model. *Journal of Neurophysiology*, 90, 3270-3282.

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