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THE IMPACT OF LONG-DURATION SPACEFLIGHT ON THE HORIZONTAL VESTIBULO-OCULAR REFLEX (HVOR)

Abstract

INTRODUCTION The Semi-Circular Canals (SCCs) and the Otoliths are the two main organs of the vestibular system responsible for balance and gaze-stabilization. Weightlessness impacts the otoliths, main gravity detectors, which is evident from the decreased ocular counter roll reflex observed after spaceflight (Hallgren et al., 2016). However, as the SCCs are not gravity-dependent, it is expected that a prolonged stay in microgravity would not affect the vestibulo-ocular reflex (VOR), generated by the SCCs. But little is known about the intricate interplay between the otoliths and the canals. Despite the number of studies that have tried to reveal the effect of microgravity on the SCCs through VOR measurements, most of them were strongly limited by a restricted sample size and short-duration missions (Clement et al., 2019; Reschke et al., 2018). This study aims to characterize the hVOR changes before and after a long duration spaceflight (>6 months) in an unprecedently large cohort of 44 pre- and post-flight vestibular measurements in cosmonauts.

MATERIAL AND METHODS 44 pre- and post-flight measurements were performed, of which 13 were from first time flyers (1F group) and 31 were from frequent flyers (FF, N=31), by exposing cosmonauts to off-axis centrifugation before and after their 6-month space mission to the ISS. Measurements were done approximately two months preflight, three days after landing and nine days after landing. The hVOR induced by the Visual and Vestibular Investigation System (VVIS) mini centrifuge was assessed and recorded with infrared googles during a 30-second acceleration phase until the maximum velocity of 254/s was reached. Extraction of nystagmi and associated computations of Slow-Phase Velocity (SPV) and Time Constant (Tc) were made using a custom MatLab routine. The Time Constant of hVOR was

then further statistically analyzed in SPSS (V.27), using a linear mixed-model with $p<0.05$ as significance threshold.

RESULTS We found a significant decrease in hVOR time constant Early postflight (R+3) and Late postflight (R+9) compared to preflight ($p<0.001$). A partial but incomplete recovery was seen nine days after the return of the cosmonauts (Late postflight).

CONCLUSION For the first time, our large sample size allowed us to reveal a significant effect of spaceflight on the hVOR. The time constant values measured in cosmonauts are in the physiological range. These findings show an interaction between the otoliths and the canals. Our hypothesis is that the effect shown after spaceflight on both the otolith and the canals are centrally mediated rather than peripheral.