THE INFLUENCE OF 2.5 G EXPOSURE ON THE MORPHOLOGY OF RAT VESTIBULAR EPITHELIA

René. J. Wubbels

Vestibular Department ENT, Academic Medical Center, PO Box 22660, 1100 DD Amsterdam, The Netherlands.

ABSTRACT

Several studies have shown that altered gravity causes changes in vestibular induced reflexes and behaviour (2,5-7), and in vestibular morphology (1,3,4). How the level of gravity affects the morphology of vestibular epithelia, however, is largely unknown. Vestibular epithelia of hypergravity (HG) exposed animals and control animals were histochemically labeled for actin and tubulin (two characteristic proteins for specific cytoskeletal structures in hair cells and supporting cells). Cellular organization, cytoskeletal structure and apical cross-sectional area were investigated.

1. METHODS

Morphological effects of prolonged exposure to HG (2.5 g) were investigated in two different experiments. At the age of one month, i.e. when vestibular end organs are fully mature, rats (N=3) were transferred from normal gravity to a HG environment inside a large radius centrifuge. After 9 months of HG exposure, the vestibular epithelia of these animals (HG-I) were inspected. Another group of rats (HG-II; N=4) were exposed to HG from conception until the age of 14 weeks. Statistical analysis has been performed by comparison of both groups of HG exposed rats to an age-matched control group. Control animals were housed under the same conditions and in the same room as the HG exposed rats.

2. RESULTS

A typical example of the sensory epithelium of a crista is shown in Fig. 1. Apart from the actin-labeled stereocilia and the tubulin-labeled kinocilia, other structural details can be seen. Actin belts (upper panel) mark the tight junctions between hair cells and supporting cells. Also, two typical tubulin structures can be distinguished (lower panel), i.e.: a densely packed bundle of microtubules in the 'neck' region of type I hair cells, and a structure which fills the apical part of supporting cells.

The apical cross-sectional area of epithelial cells of HG-I rats appears to be smaller in all end organs. Area reduction is 1.9% in the saccule (not significant), 5.0% in the utricle ($p<0.005$), and 11.6% in the crista ($p<<0.001$). There are no morphological indications for a deterioration of vestibular functioning (8).

The cross-sectional area of epithelial cells of HG-II rats appears to be larger in all end organs. Area increase is 7.0% in the utricle ($p<0.005$), and 8.2% in the crista

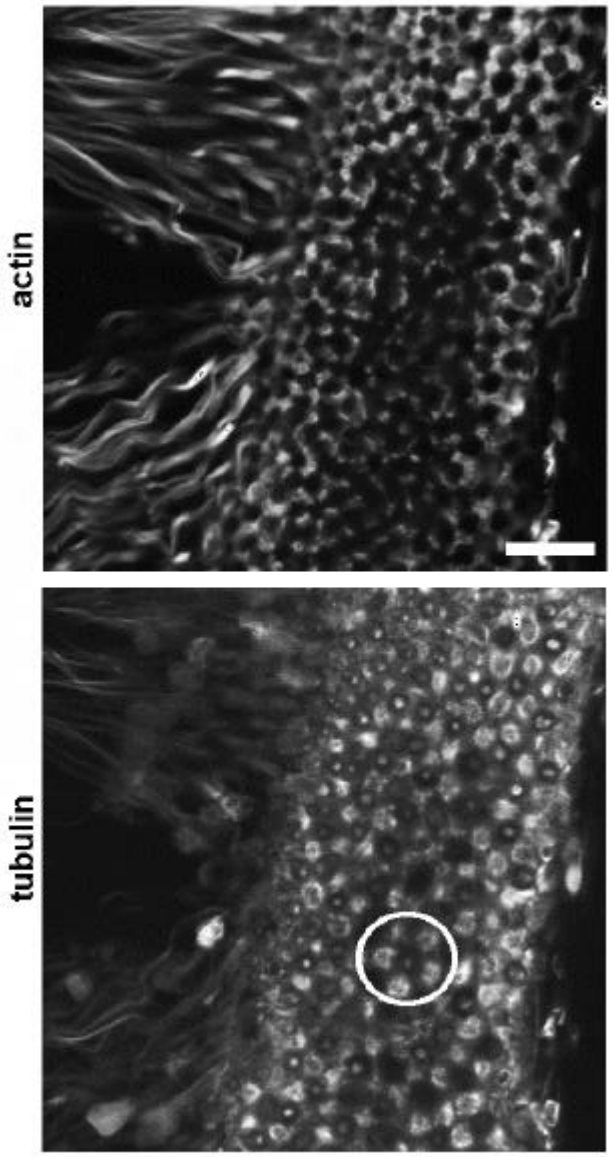

Figure 1: Crista of a 245 days old control rat labeled for actin and tubulin. On the left, long hair bundles, with their stereocilia (upper panel) and kinocilia (lower panel), are visible. The white circle indicates a hair cell (centre) and 5 supporting cells. In general, hair cells are surrounded by 4-6 supporting cells in all vestibular end organs. Actin belts (upper panel), which mark the outline of epithelial cells, were used to calculate cross-sectional area. Hypergravity exposure had no effect on characteristic cytoskeletal structures. Scale bar: 20 µm.

($p<<0.001$). Hair cells and supporting cells appear to be intact. Cellular arrangement and the proportion of different cell types within the epithelia is normal (9).
The two control groups were extended with rats of three other ages. The complete (normal gravity exposed) control group comprises rats of the following ages: 98 (N=4), 137 (N=3), 245 (N=1), 281 (N=3) and 373 days (N=2). Data are shown in Fig. 2, together with the results of the two HG exposed groups.

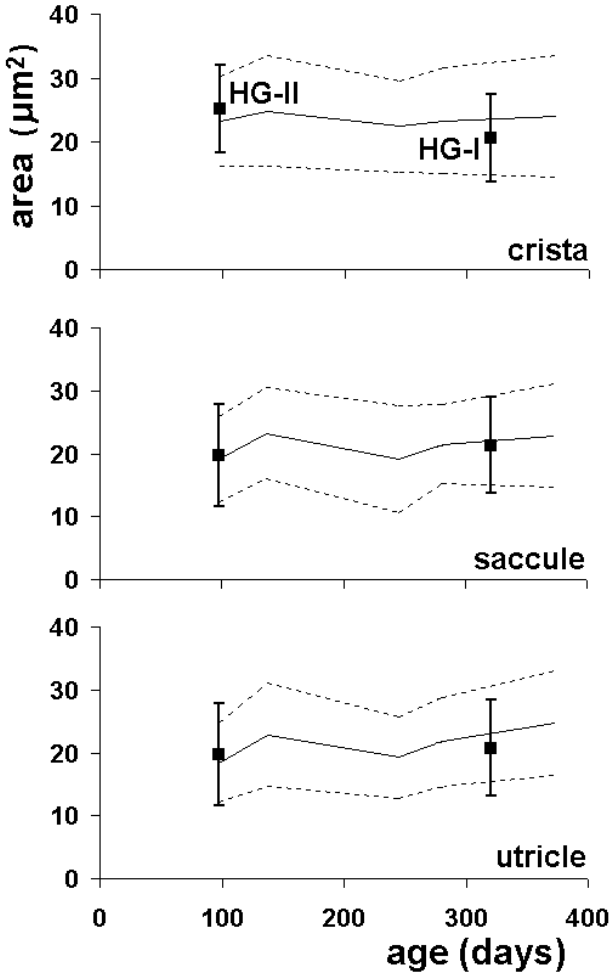

Figure 2: Mean apical cross-sectional area of epithelial cells of each of the vestibular end organs. Solid line (controls) shows the average area as a function of age; dashed lines show average ± standard deviation. Results of the two groups of hypergravity-exposed rats (?) appear to be normal.

3. CONCLUSION

Apparently, HG exposure of a fully mature vestibular system reduces the size of epithelial cells, while HG exposure during ontogeny enlarges cell size. These results suggest the presence of a gravity-dependent mechanism during a particular developmental stage, which irreversibly increases cell size. This putative critical period has to occur before the age of one month. Thereafter, HG exposure only appears to reduce cell growth. In both experiments that were performed the effect of HG exposure is largest in the organs which detect angular acceleration and smaller in the organs which detect linear acceleration including gravity.
Although statistics are significant and consistent, the differences between HG exposed and control animals are small and the variance is large. Furthermore, the observed consistency can, most probably, be explained by a strong correlation between cell size within individual sensory organs and also between the vestibular end organs of each individual animal. Thus, it appears that the effect of prolonged HG exposure on vestibular epithelial morphology is small or even negligible.

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