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EDITORIAL:

Hearing and sports: a bidirectional interaction [Audición y Control motor: Una relación recíproca]

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Introduction

Motor control is crucially dependent on many sensory inputs that involve classically the proprioreceptors located in the tendons, joints and the muscle itself as well as inputs from the vestibular organ and eyes (Fitzpatrick and McCloskey, 1994). However, additional sensory input from the auditory system is often necessary to perform the sport-associated complex motor-tasks. This holds not only for team sports that requires continuous communication with the other players but also for others such as figure skating or gymnastics where the movements of the body need to be coordinated with music. In addition, hearing is also important for avoiding accidents e.g. during skiing to recognize other people on the same track. Conversely, specific sports wear used in these sports may negatively influence hearing as it was shown for ski helmets that reduce perception of safety-relevant frequencies (Ruedl, Kopp, Burtscher, Zorowka, Weichbold, Stephan, Koci and Seebacher, 2014; Tudor, Ruzic, Bencic, Sestan and Bonifacic, 2010). Moreover, the reaction time and force generated during voluntary contractions could be influenced by sound. For instance, runners closer to the starter's pistol at Olympic Games react sooner than runners farther away (Brown, Kenwell, Maraj and Collins, 2008). Finally, hearing could even influence the overall physical fitness as it might be reduced in deaf children (Hartman, Visscher and Houwen, 2007) although other studies could not confirm (Wierzbicka-Damska, Samolyk, Jethon, Wiercinska and Murawska-Cialowicz, 2005). In the elderly, sensory deficits such as poor vision and hearing may increase the risk of mobility decline (Viljanen, Kaprio, Pyykko, Sorri, Koskenvuo and Rantanen, 2009a; Viljanen, Kaprio, Pyykko, Sorri, Pajala, Kauppinen, Koskenvuo and Rantanen, 2009b).

In contrast, the influence of sports on hearing might be generally negative. Especially for divers or parachutists rapid and strong changes in atmospheric pressure gradients between the environment and the middle ear can result in barotraumas (Lynch and Deaton, 2014). More common however isnoise induced hearing loss associated with sports. Sport events such as for example shooting (Flamme, Stewart, Meinke, Lankford and Rasmussen, 2011) or soccer are associated with quite extreme noise exposure. This holds not only for the physically active people performing the sports but also and sometimes even more for spectators or other bystanders watching the sports regularly (Flamme and Williams, 2013; Ramma, 2011; Ramma, Petersen and Singh, 2011). As most people start generally early in life performing or attending their preferred sport and continue to do so all over their life the damage on their inner ear is cumulative.These domains are classified from body, individual and societal perspectives by means of two lists: a list of body functions and structures, and a list of domains of activity and participation.

Current Scientific Research

In general current scientific research focuses on the unwanted “side effects” of sports on hearing e.g. barotrauma that can occur with highest probability among the different kinds of sport during scuba diving or skydiving (Lynch et al., 2014). Secondly, noise-induced hearing loss is an important issue in this context as sport similar to many other leisure activities is often associated with quite high sound pressure levels (Clark, 1991). Finally, the effect of protective wear on sound perception and subsequent safety-relevant behavior of the athlete is a significant research topic (Evans, Gervais, Heard, Valley and Lowenstein, 2009; Ruedl et al., 2014; Tudor et al., 2010).

Performing sports with fast and extreme changes in pressure differential between environment and middle ear or sinuses such as scuba diving and skydiving is a risk to acquire barotrauma injuries in these structures. Early symptoms include ear pain, dizziness, and muffled hearing. When extreme pressure gradients are not relieved, middle ear hematoma and/or rupture of the tympanic membrane can occur. Similarly, this affects the sinuses as well. Without proper prevention strategies every 10m depth change adds a pressure differential of 1 atm across the tympanic membrane. Swallowing, yawning, and Valsalva maneuvers open the Eustachian tube and allow pressure relief across the tympanic membrane. However, if the Eustachian tube is not patent, for instance due to an upper respiratory tract infection, allergies, or abnormal anatomy, these measures do not work. A risk to develop comparable symptoms and injuries as scuba divers have people performing parachuting, skydiving, paragliding, parasailing, hang gliding or wingsuit flying but also heliskiing and heliboarding. However the risk and resulting symptoms for barotrauma is generally lower in these sports as the pressure changes are less steep compared to scuba diving. Exceptions are skydiving and high altitude - low opening (HALO) parachuting (Glorioso, Batts and Ward, 1999; Hodkinson, 2011).

Noise-induced hearing loss is a very common problem and not only induced by performing or watching sports as any kind of noise can induce either instantly (acute acoustic trauma), when loud enough (130-140 dBA), or in a more or less delayed manner when repeatedly exposed to noise (above 75-80) (Dobie, 2001; Lawton, 2001). Therefore, noise exposure is legislatively regulated in industry to a maximum permissible exposure to accumulated noise, equivalent to an 8-hour continuous noise level of 85 dBA (Neitzel, Seixas, Goldman and Daniell, 2004). However many kinds of sports are associated with considerable noise exposure and is in addition attended or performed by quite a number of people. In this context soccer games have been investigated as often very loud noise is produced by the spectators sometimes by using e.g. Vuvuzelas to express their fun or to cheer on their teams (Ramma; Ramma et al., 2011). This particular instrument has a broad frequency spectrum between 75 Hz and 20 kHz and a sound pressure level of up to 105 dBA. Consequently, significant hearing impairment could be detected in people blowing the Vuvuzela or sitting within 1m distant from it after a single soccer match (Ramma et al., 2011).

Sports wear such as ski helmets can reduce sound perception, which may result in significant safety issues (Ruedl et al., 2014; Tudor et al., 2010). However, which specific features result in reduced perception of specific safety-relevant frequencies has not investigated specifically. In addition, the effect on hearing appears to depend very much on the details in construction of the helmet as others found that wearing a rugby helmet does not alter the perception of sound (Kieran, Dunne, Hughes and Fenton, 2008). Thus, it remains to elucidate which design features adversely reduce sound perception and should be avoided.

Limitations of the studies

It appears that so far the interactions between sports and sound perception is an underrated scientific topic. However as people live longer and are more aware and interested in their physical fitness this might need to be changed. With increasing age the lifelong noise exposure accumulates and might result in preterm presbycusis. Therefore the sport-associated noise exposure, risks to acquire a braotrauma as well as the way acoustic perception is necessary for save performance of sport should become a scientific topic of growing interest. On the other hand it has been shown that better cardiovascular fitness may reduce presbycusis as long as the noise exposure during the life was not unusual high (Hutchinson, Alessio and Baiduc, 2010). This is a quite important finding as to the question of maintaining health up to a high age but unfortunately has been not further investigates. Overall broad epidemiologic, systematic studies regarding time spent with performing or attending sports, cardiovascular fitness, measurements (or at least estimates) of the noise exposure in the respective activities and development of presbycusis are missing. Finally the scientific basis regarding design features of sport helmets and their effect on sound perception and resulting safety issues is only marginally investigated so far.

Future research

Because hearing impairment is not directly life-threatening it is tended to be an underrated medical problem. However as people live longer our society gets older and we all want to enjoy our twilight years. Natural aging including the development of age related hearing loss (presbycusis) appears to be delayed in active compared to sedentary man. Thus, physical activity and subsequent gain or maintenance of cardiovascular fitness increases overall quality of life and health including sensory performance (Hutchinson et al., 2010; Wierzbicka-Damska et al., 2005). The other way around poor hearing is a risk factor for increased mortality (Feeny, Huguet, McFarland, Kaplan, Orpana and Eckstrom, 2012; Viljanen et al., 2009a; Viljanen et al., 2009b). Consequently it is desirable to better understand the effect of sports on hearing and vice versa. Research on this topic should result at least in recommendations how to behave and what to avoid for increasing lifespan at maximum health.

Thus, my prediction is that research on the bidirectional interconnection between hearing and physical activity will gain increasing interest of scientists all over the globe.

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