Nutrition, physical activity, and hearing health:

Helping the world hear

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A multitude of studies have been published on the relationship between health outcomes and role of nutrients, foods, dietary patterns, supplements, drugs and physical activity. Hearing health is also included among this literature. However, the study of lifestyle-health relationships is complicated by the large number of chemicals we consume, complex biochemical interactions involved (e.g., genetics, metabolism), environmental/population factors and study design/biostatistical considerations that influence outcomes. Despite these significant limitations, there is a growing mass of literature demonstrating relationships between nutrition, physical activity, other lifestyle factors (e.g., smoking) and hearing health.

Global Implications

Nutrition is recognized as a meaningful determinant of many major chronic health complications, including cardiovascular disease, metabolic disease, neurological disease and cancer. The second half of the 20th century had seen major modifications in diet, first in industrial regions and then in developing countries. The traditional, largely plant-based diets have been swiftly replaced by higher fat, energy-dense diets with substantial content of animal-based foods. While diet is critical, another important part of the equation is physical activity with progressive shifts of lifestyle toward more sedentary patterns [WHO, 2003].

There is a need for action to not only counter the spread of chronic disease, but also the emerging epidemic of sensory dysfunctions such as hearing loss. It is worth noting that prevention of chronic disease could also result in at least a surrogate effect of mitigating the risk of hearing loss [Cruickshanks et al., 2015; Bainbridge & Wallhagen, 2014]. Approaches for modification of nutrition, physical activity and other lifestyle factors may differ depending on geographic region, age, and sex of target population and sociocultural issues. In general, healthy diet and living are fairly universal concepts, but the challenges can be unique based on region. Even in developed countries like the United States, poverty and access to nutritional foods can be an issue, but a significant element at play is health and nutritional literacy to increase acceptance of health-promoting behaviors.

Preventing Childhood Hearing Loss

In developing countries, there is a cumulative burden of malnutrition/undernutrition, poor access to healthcare resources and disease. These factors have implications for early- and later-developed forms of hearing loss. It is estimated that roughly 32 million children in the world have hearing loss, 9 percent of the global population with hearing aids [WHO, 2016]. Currently, research is very limited in examining the role of nutrition during prenatal, perinatal, and childhood development on hearing and the risk for hearing loss. Malnourishment in infants has been associated with increase odds of significant sensorineural hearing loss [Olusanya, 2010].

Iodine deficiency is the greatest single preventable cause of brain damage and intellectual disability worldwide, affecting more than 700 million people [WHO/UNICEF, 1999]. Vitamin A deficiency remains the single greatest preventable cause of childhood
blindness [WHO/UNICEF, 1995]. Prematurity and low-birth weight, which are commonly related to prenatal and perinatal malnutrition, can significantly influence growth and physical and mental capacity in children [De Onis, Blossner, & Villar, 1998]. These common consequences of poor nutrition [iodine and vitamin A deficiencies] also have direct and indirect relationships to hearing [Valeix, Preziosi, Rossignol, Farnier, & Hercberg, 1994; Emmett & West, 2014]. Prematurity and low-birth weight are well-known risk factors for hearing dysfunction and present issues for diagnostics due to maturation issues that can influence testing [Koenighofer, Parzefall, Ramsebner, Lucas, & Frei, 2015; Karaca, Oysu, Toros, Naiboglu, & Verim, 2014; Casali & Santos, 2010; Robertson, Howarth, Bork, & Dinu, 2009]. Other specific nutrient relationships have been indicated. Attias et al. [2012] showed a relationship between thiamine-deficient formula and auditory neuropathy spectrum disorder. Similar relationships to auditory neural maturation have been shown with iron-deficiency [Choudhury et al., 2015].

An emerging issue for developing countries is not only malnutrition, but also obesity. Change in traditional diets and influx of processed energy-dense foods (in lieu of nutrient-dense foods) now creates individuals that are not only malnourished/nutrient deficient, but also obese. Obesity and early factors contributing to obesity have been correlated with risk for hearing loss in children and as acquired in adulthood [Lawani, Katz, Liu, Kim, & Weitzman, 2013; Barrenas, Jonsson, Tuvemo, Hellsrom, & Lundgren, 2005].

Childhood hearing loss is a significant issue particularly in regions with poor sociocultural beliefs regarding hearing loss and limited access to appropriate audiological and educational resources. The implications of hearing loss in children involve substantial negative influences on development, educational achievement and possibly sociocultural status. However, hearing loss and deafness are not always perceived as negative. Deaf culture remains vibrant today in the U.S. and other developed countries. As a rarer example in a developing country, a remote Balinese village of Bengkala with a high incidence of deafness related to the recessive gene DFNB3 [located on chromosome 17p11.2 and leads to a mutation in myosin15A] perceive deafness not as an abnormality, but a gift from Dewa Kolok, the god of the deaf. The villagers include both hearing and deaf, and over the centuries have developed their own unique sign language [Sumitra, 2015].

Very limited data exist on the role of nutrition [prenatal and perinatal] in the prevention of childhood hearing loss. However, addressing nutritional deficiencies is recognized as a key factor in improving outcomes and health for children, including mitigating the risk of hearing loss.

**Hearing for a Lifetime**

Congenital or childhood hearing loss represents a significant global concern, but over 90 percent of the 360 million people worldwide with hearing loss are adults. The implications for acquired hearing loss in adults has commonly been dismissed or seen as an inevitable part of the aging process. In part, the terms presbycusis [from Greek presby “old” and akousis “hearing”] and age-related hearing loss have been misinterpreted as “age” as the referred cause of hearing loss. In reality, these terms refer to a lifetime of noise exposure and other environmental factors, health issues, ototoxic medications, nutrition, physical activity, other lifestyle factors and genetics that contribute to this acquired “age-related” hearing loss. The following are considered determinants that contribute to the increased risk of hearing loss (with controlled age): significant noise exposure, Caucasian, male, use of ototoxic drugs and health [diabetes, cardiovascular disease, etc.]. The reciprocal of the listed factors reduces risk despite age. Recently, the dismissive attitude toward hearing loss acquired during a lifetime has been shifting. Growing evidence citing the association of hearing loss with an increased risk for cognitive decline and risk of falls has brought greater attention to hearing loss in adults as a global public health issue [Tay et al., 2006; Lin et al., 2013; Lin & Ferrucci, 2012].
As one would expect, there is also evidence that nutritional status and physical activity are also related to healthy aging, cognitive decline and risk of falls (Khaw, 1997; Morris, 2016; Gagliardi, Papa, Postacchini, & Giuli, 2016). The relationship of sensory loss (both vision and hearing), nutrition and physical activity with healthy aging appears self-evident, but research specifically in diet, physical activity and hearing is fairly scarce. One of the earliest attempts to examine the influence of diet on hearing was performed by a surgeon named Samuel Rosen over 50 years ago. Rosen’s seminal report was based on data collected in the Mabaan tribe in Sudan. The tribe was described as relatively noise-free with frugal diets and nearly nonexistent evidence of cardiovascular disease. Audiometry determined essentially normal hearing sensitivity through the eighth decade of life (Rosen, Bergman, Plester, El-Mofty, & Satti, 1962). There was a decline with age, specifically to higher frequencies consistent with presbycusis, but the thresholds were still better than 25dB HL at all ages.

Since this seminal report, a handful of studies have examined the relationship between nutrition and hearing in humans. Some have focused on specific nutrient deficiencies or inadequacies as related to hearing loss, others on elevated intake of specific nutrients. In general, these studies demonstrate that diets inadequate in micronutrients can be related to an increased risk of hearing loss. Diets high in caloric intake, high in dietary lipids (particularly saturated versions), and high glycemic index food intake increased the risk of hearing loss, while diets rich in B-complex vitamins and nutrients with antioxidant properties can reduce the risk of hearing loss (Spankovich, 2015, 2014). However, there is no evidence of a super-nutrient that will preserve hearing. This makes sense, since the function of our auditory system, as with the rest of our body, is dependent on an array of complex biochemical processes.

The need for a nutrient-dense varied diet is paramount. The question is how can we effectively achieve a healthy diet? Dietary supplements and their role in prevention of chronic disease, healthy aging and hearing loss remain unclear. The target population for intervention and strategy of prevention are likely critical. Individuals or populations that are deficient in specific nutrients may benefit from supplement strategies (e.g., fortified food or capsule/pills/injections). The first nutrient to be added as a fortification was iodine to salt in the early 1920s. However, the role of dietary supplements is less clear for populations without true deficiencies. Meta-analysis of antioxidant supplements in prevention of chronic disease showed no protective benefit and possible harmful consequences in well-nourished populations (Bjelakovic, Nikolova, & Gluud, 2014). Similar evidence of negative influence of supplements has been shown for hearing (Curhan et al., 2015) and intake of vitamin C. A complicating factor is, in addition to diets that are inadequate in nutrients, there is excessive intake of unhealthy caloric-dense foods. Unfortunately, supplements cannot counteract an unhealthy diet or sedentary lifestyle. This does not mean supplements cannot play a role in healthy aging and healthy hearing, but we should be cognizant of their limitations. For example, the use of antioxidants as otoprotectants may be an effective acute strategy for noise-induced hearing loss, but this does not mean that long-term use will convey benefit for hearing loss acquired over a lifetime. In addition, there are notable concerns for long-term use of antioxidant supplements (Mursu 2011; Klein et al., 2011). It is worth noting that no studies have shown that antioxidants derived via diet (not supplements) have negative consequences (NIH, 2006). In addition, physical activity level appears to be a significant factor as well (Loprinzi, 2013).

Rather than focusing on specific nutrients, there are a series of emerging analyses demonstrating the relationship between dietary patterns and hearing loss. Dietary patterns consider the type of diet based on food types (e.g., vegetarian), statistical patterns and/or indices of quality. One example is the Healthy Eating Index (HEI). The HEI is a measure of how well a diet conforms to the recommended dietary guidelines of the U.S. Department of Agriculture. The HEI has gone
Nutrition, physical activity, and hearing health

through several revisions over the years and further information can be found on the following website: http://www.cnpp.usda.gov/healthyeatingindex. In general, the HEI provides a score on a scale of 0 to 100, with 100 being the “healthy” maximum score. The score is a sum of subcomponents that examine variable aspects of diet health as prescribed by the USDA. Some components provide higher scores with higher dietary intake (e.g., vegetables) and others provide lower scores with higher dietary intake (e.g., sodium).

Three recent analyses of the National Health and Nutrition Examination Survey (NHANES) database look at the relationship between HEI and hearing loss and noise history (Spankovich & Le Prell, 2014), and tinnitus (in preparation). The NHANES is an ongoing cross-sectional survey of the civilian non-institutionalized population of the U.S. Every two years, approximately 10,000 individuals are selected at random within specific demographic distributions so as to be representative of the U.S. population. The study involves questionnaires and examinations to detail health status of the participants, including hearing loss. The hearing results in general show a significant relationship between the HEI and hearing loss and tinnitus where higher HEI (better diet) is associated with lower thresholds (better hearing) and reduced report of tinnitus. Figure 1 shows high-frequency pure-tone average thresholds for participants grouped into good, intermediate and poor HEI scores. Specific subcomponents showing relationships to better hearing include higher intake of vegetables, fruits, and variety of diet and lower intake of sodium and saturated fat. The limitation of this dataset is lack of prospective data, and thus analyses are limited to cross-sectional relationships and causal relationships cannot be determined.

Summary and Questions

The understanding of nutrition and relationship to hearing loss and prevention of hearing loss is still in its infancy. We know that many nutrients and trace chemicals we derive from our diet can influence the risk of hearing loss. There is a rich literature of animal-model-based data to support this idea (Le Prell & Spankovich, 2013). However, translation of this data to humans is not simple, as many factors play roles that are difficult to control, and longitudinal studies are lacking. Many of the dietary components associated with hearing loss (e.g., higher intake of fruits and vegetables) are also associated with reduced or increased risk of chronic disease (Liu, 2013).

Numerous questions remain as to the interaction between nutrition, physical activity, chronic disease and hearing loss for global public health intervention. Is there a specific nutrient combination for prevention of hearing loss/tinnitus? What is the application of supplements for acute and long-term prevention? What is the role of genetics in guiding best response to diet and nutrition to prevent hearing loss/tinnitus or other chronic health issues.
[called nutrigenetics]? Will these recommendations be dependent on the etiology of the hearing loss? Will these recommendations be dependent on geographic and population factors?

Though we do not have the answers to these questions (or many others), we do have accumulating evidence that a healthier lifestyle is related to healthier hearing. We must begin to incorporate dialogue with our patients that hearing loss is multifactorial and not an inevitable process of aging. Rather, there are changes that can be made to alter risk, behavioral changes that may provide both direct and indirect mechanisms for prevention. Prevention of hearing loss, whether primary or secondary in nature is not limited to using hearing protection devices and avoiding ototoxic drugs. Audiology as a health care field must look beyond the ear and consider factors beyond the usual suspects (noise, age and drugs) in prevention of hearing loss to more effectively serve the public hearing health.

References


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