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Subjective Fatigue in Children With Hearing Loss: Some Preliminary Findings

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Abstract

Purpose—In this study, the authors examined the effect of hearing loss on subjective reports of fatigue in school-age children using a standardized measure.

Methods—As part of a larger ongoing study, the authors obtained subjective ratings of fatigue using the Pediatric Quality of Life Inventory (PedsQL) Multidimensional Fatigue Scale (Varni, Burwinkle, Katz, Meeske, & Dickinson, 2002). This standardized scale provides a measure of general fatigue, sleep/rest fatigue, cognitive fatigue, and an overall composite measure of fatigue. To date, data from 10 children with hearing loss (CHL) and 10 age-matched children with normal hearing (CNH) have been analyzed.

Results—These preliminary results show that subjective fatigue is increased in school-age children with hearing loss (Cohen's $d = 0.78–1.90$). In addition, the impact of hearing loss on fatigue in school-age children appears pervasive across multiple domains (general, sleep/rest, and cognitive fatigue).

Conclusion—School-age CHL reported significantly more fatigue than did CNH. These preliminary data are important given the negative academic and psychosocial consequences associated with fatigue. Further research is needed to determine the underlying mechanisms responsible for this increased fatigue in school-age children with hearing loss, and to identify factors that may modulate (e.g., degree of loss) and mediate (e.g., hearing aid or cochlear implant use) its impact.

Keywords

children; fatigue; hearing loss

Fatigue is a common but important complaint of individuals with a wide range of chronic health conditions (Evans & Wickstrom, 1999; Hardy & Studenski, 2010). Children with fatigue associated with cancer, sleep deprivation, rheumatic diseases, and chronic fatigue syndrome (CFS) experience a variety of negative social and psycho-educational problems (for reviews, see Eddy & Cruz, 2007; Garralda & Rangel, 2002). Anecdotal reports from parents, teachers, and clinicians have long suggested that children with sensorineural hearing

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loss (CHL) are also at increased risk for fatigue and its negative effects (Bess, Dodd-Murphy, & Parker, 1998; Hicks & Tharpe, 2002; Ross, 1992). Although empirical work in this area is limited, one could easily speculate that toward the end of a school day CHL may be physically and mentally spent as a result of focusing intently on a teacher's speech and the conversations of other children. The importance and impact of fatigue associated with hearing loss is readily apparent from the personal accounts proffered by adults with hearing loss: “I go to bed most nights with nothing left. It takes so much energy to participate in conversations all day, that I'm often asleep within minutes' (Portis, 2008), and “When you are hard of hearing you struggle to hear; when you struggle to hear you get tired; when you get tired you get frustrated; when you get frustrated you get bored; when you get bored you quit” (Pichora-Fuller, 2003, p. S28).

For children, the classroom environment itself increases the potential for fatigue. Classrooms are notoriously noisy; noise levels may exceed recommended standards by up to 30 dB in even unoccupied classrooms (Crandell & Smaldino, 2000; Knecht, Nelson, Whitelaw, & Feth, 2002). Classrooms that are occupied by teachers and students are even noisier (for a review, see Shield & Dockrell, 2003). High levels of background noise, which are especially challenging for CHL, are known to increase stress levels and fatigue even in school-age children with normal hearing (CNH; Wålinder, Gunnarsson, Runeson, & Smedje, 2007). The potential impact of increased stress and fatigue on children is important because these factors could compromise a child's ability to learn in a noisy classroom environment. Moreover, the negative effects of recurrent fatigue on academic performance are well documented among children with chronic health conditions (e.g., cancer, CFS). Children suffering from recurrent fatigue tend to miss more school (for reasons unrelated to physical ailments); are at increased risk for poor academic performance, making them less prepared to advance; and are more likely to fail a grade than their nonfatigued peers (Curcio, Ferrara, & De Gennaro, 2006; Hockenberry-Eaton et al., 1999; Nagane, 2004; Ravid, Afek, Suraiya, Shahar, & Pillar, 2009a, 2009b; Stoff, Bacon, & White, 1989).

Recent work in adults with hearing loss has shown empirically that sustained speech processing demands, such as decoding speech in noise, can lead to subjective reports of fatigue, particularly when listening without hearing aids (Hornsby, 2013). The mental demands and listening environment of a typical school day are especially challenging, potentially making CHL even more susceptible to the consequences of hearing-loss-related fatigue than adults. Thus, although fatigue in CHL is intuitive and supported by anecdotal reports, systematic work examining the link between hearing loss and fatigue in children is almost nonexistent.

Bess et al. (1998) provided some support for the hypothesis that school-age children are at increased risk for fatigue. They used the COOP Adolescent Chart Method (Nelson et al., 1987; Wasson, Kairys, Nelson, Kalishman, & Baribeau, 1994) to measure multiple dimensions of functional health status, including energy (a construct related to fatigue), in CHL and CNH. The CHL in their study had mild bilateral (average thresholds at 1, 2, and 4 kHz of 20– 40 dB HL), high-frequency (at least two thresholds above 2 kHz of > 25 dB HL), or unilateral losses. Despite the mild losses, the CHL reported that they had less energy (and hence were more fatigued) than CNH. In contrast, Hicks and Tharpe (2002) used the same instrument but did not report differences between their CHL and an age-matched group of CNH. Although the discrepant findings of Bess et al. and Hicks and Tharpe may be due to differences between study participants and study design, this could also reflect the lack of sensitivity of the COOP itself for detecting fatigue. The COOP is an appropriate tool for screening function in busy physician practices. It was not, however, designed or validated for direct assessment of fatigue. In fact, the work we report here is the first to quantify fatigue in school-age CHL using a standardized and validated measure of fatigue. This preliminary report is thus an important first step toward improving our understanding of the relationship between fatigue and hearing loss in children.

Method

Study procedures were approved by the Vanderbilt University Institutional Review Board. Participants were recruited from Vanderbilt's pediatric audiology clinic, through an advertisement in a local parenting magazine, and through the Vanderbilt Kennedy Center's Studyfinder website. This report is preliminary data obtained as part of a larger, ongoing, study examining the effects of listening effort and fatigue on learning in school-age CHL.

Participants

Participants included 10 CHL (M_{age} = 10;3 [years; months]; range = 6;3–12;9) and 10 age-matched CNH (M_{age} = 10;2; range = 6;2-12;9) who were selected from a pool of 30 CNH currently enrolled in the larger study. CNH were selected to achieve age-matches that were within ±6 months of the chronological age of each child with hearing impairment (±3 months for all but one participant). All CNH had bilateral pure-tone air conduction thresholds ≤ 15 dB at octave frequencies between 250 and 8000 Hz and normal tympanometric peak pressure. Language ability was measured using the core language index of the Clinical Evaluation of Language Fundamentals—Fourth Edition (CELF–4; Semel, Wiig, & Secord, 2003). All CNH had average or above-average scores. However, as expected for an age-matched group comparison, language abilities were poorer for the CHL, with only three children scoring in, or above, the average range. All participants had nonverbal intelligence within the typical range as measured by the Test of Nonverbal Intelligence—Fourth Edition (Brown, Sherbenou, & Johnson, 2010), and all were monolingual English speakers. Nine CHL were developing spoken English only and one used total communication.

Within the CHL group, there were five children with bilateral hearing aids, four children with cochlear implants, and one child with unilateral hearing loss. The age at which the CHL first received amplification or were implanted ranged from 18 to 132 months, resulting in hearing ages (time since receiving initial amplification) of 10 to 123 months. All CHL used amplification full time at school and seven of 10 used an FM system in the classroom, per parent report. Audio-metric thresholds and characteristics for the CHL are shown in Table 1.

Fatigue Measure

The Pediatric Quality of Life Inventory Multidimensional Fatigue Scale (PedsQL MFS; Varni, et al., 2002) was used to assess children's self-reported perceptions of fatigue. This tool has been validated for use with children between the ages of 5 and 18 years (Varni et al., 2002; Varni, Burwinkle, & Szer, 2004). The PedsQL MFS is a standardized measure composed of three subscales (each containing six items): (a) General Fatigue (e.g., “I feel tired”); (b) Sleep/ Rest Fatigue (e.g., “I rest a lot”); and (c) Cognitive Fatigue (e.g., “It is hard for me to think quickly”). A Total (composite) Fatigue score is also calculated from the subscales. Children are asked how much of a problem each item has been over the past month. The developers of the PedsQL MFS used classical and modern measurement theories — more specifically, they based the scale on research and clinical experiences with pediatric health care conditions; considered the research literature on instrument development; obtained input from focus groups, individual focus interviews, and cognitive interviews; and conducted item analysis and generation, pretesting, and field testing. The PedsQL MFS has been used by children with a variety of chronic health conditions, including cancer (Varni et al., 2002), obesity (Varni, Limbers, Bryant, & Wilson, 2010), rheumatic disease (Varni et al., 2004), Type 1 diabetes (Varni, Limbers, Bryant, & Wilson, 2009), and children with short stature (Varni, Limbers, Bryant, & Wilson, 2012). Research has shown that the test is clinically feasible, easy to administer, and possesses good internal consistency reliability and construct validity (Varni et al., 2002, 2004).

Procedure

Written parental consent, as well as child assent, was obtained before beginning study procedures. As part of the larger ongoing study, participants completed audiologic, language, and nonverbal intelligence testing during an initial visit. Also at this visit, parents completed a demographic questionnaire, and children completed subjective ratings of fatigue using the PedsQL MFS. This article focuses on the children's subjective ratings of fatigue.

A trained research assistant administered the age-appropriate PedsQL MFS: Young Child (ages 5–7) or Child (ages 8–12). For the Young Child form, the research assistant read each item and asked the child to respond by pointing to the corresponding happy to sad face. For the Child form, the research assistant read each item and asked the child to respond by circling the selected item. Total time to complete the PedsQL MFS was approximately 5 min per participant.

In accord with published scoring instructions, items were reverse-scored and linearly transformed to a 0–100 scale (0 = 100, 1 = 75, 2 = 50, 3 = 25, 4 = 0), so that higher scores indicate less fatigue. Subscale fatigue scores were calculated using the procedures in the test manual. Specifically, item ratings in each domain (general, sleep, and cognitive) were summed and then divided by the number of scale items answered in a given domain. The overall fatigue score was calculated by summing test items across all domains and dividing by the total number of items answered. In the data reported here, there were no missing items. To assure reliability in scoring, all test forms were double-scored by a research assistant familiar with test scoring. Data were entered into REDCap, a secure, web-based application for building and managing online databases, housed at Vanderbilt University (redcap.vanderbilt.edu). First, a research assistant entered the transformed scores into the REDCap database, then a second research assistant double-checked data entry for all participants. For each fatigue subscale as well as the overall fatigue score, group means were compared using independent-sample *t* tests.

Results

In all our comparisons, on average, CHL reported greater fatigue than the age-matched CNH. Total and subscale fatigue scores for the CHL and CNH are shown in Figure 1. Recall that higher PedsQL MFS scores reflect less fatigue. Specifically, Total Fatigue, the composite of the subscale scores, was greater for CHL ($M = 53.6$, $SD = 18.8$) than CNH ($M = 76.1$, $SD = 12.3$), $t(18) = 3.17$, $p < .01$, $d = 1.42$. On the General Fatigue subscale, CHL reported more fatigue ($M = 55.0$, $SD = 20.7$) than CNH ($M = 85.0$, $SD = 8.4$), $t(18) = 4.25$, $p < .001$, $d = 1.90$. Likewise, on the Sleep/Rest Fatigue subscale, CHL reported more fatigue ($M = 52.5$, $SD = 24.1$) than CNH ($M = 72.5$, $SD = 14.7$), $t(18) = 2.24$, $p < .05$, $d = 1.00$. On the Cognitive Fatigue subscale, CHL again reported more fatigue ($M = 53.3$, $SD = 24.7$) than CNH ($M = 70.83$, $SD = 19.6$). Although this difference was not statistically significant, $t(18) = 1.755$, $p = .09$, $d = 0.78$, Cohen's *d* indicated a large effect.

Although mean fatigue ratings were on average greater for CHL, variability was also higher, resulting in substantial overlap in fatigue ratings between groups across all domains. For example, ratings of general fatigue for the CNH ranged from approximately 71 to 96 (25-point range). In contrast, ratings of general fatigue for CHL ranged from 25 to 92 (67-point range). Similar variation in the range of scores between groups was observed across all domains.

Discussion

Fatigue is a complex multidimensional construct that can be described as a mood, a feeling of tiredness, exhaustion, or a lack of energy. It is commonly associated with feelings of diminished focus, concentration, alertness, mental energy, and efficiency (DeLuca, 2005; Lieberman, 2007). Anecdotal reports and intuition have long suggested that school-age CHL were at increased risk for fatigue compared to their peers without hearing loss. Utilizing a standardized and validated measure of fatigue (the PedsQL MFS), the results of this study indicate that there are indeed important differences in reported fatigue in CHL. Across all fatigue domains, CHL reported they were more fatigued than an age-matched group of CNH (see Figure 1). In fact, these preliminary data suggest that the fatigue experienced by our group of CHL was substantial, even in comparison to children with other chronic health conditions. Using the PedsQL MFS, Varni and colleagues reported mean fatigue scores of children suffering from cancer, rheumatoid arthritis, diabetes, and obesity (Varni et al., 2002, 2004, 2009, 2010). The fatigue experienced by these children was substantially less than that experienced by the CHL in this study. For example, CHL reported a mean Total Fatigue score (a composite across all domains) of 53.6. In contrast, fatigue ratings from children with other chronic health conditions were substantially higher (recall that higher numbers reflect less fatigue). Mean Total Fatigue scores ranged from 67.7 (for children with obesity; Varni et al., 2010) to 75.7 (for a sample of pediatric cancer patients; Varni et al., 2002). Similar differences were seen across all fatigue domains (i.e., general, sleep, and cognitive). Total Fatigue scores for healthy control groups in these studies ranged from 80.5 to 82.2, similar to the total score of 76.1 for the CNH in the current study.

These findings may actually underestimate the impact of fatigue in CHL. The PedsQL MFS was not developed for CHL but for children with other chronic conditions such as cancer and multiple sclerosis. It is possible that a fatigue scale that included items weighted for fatigue from speech processing/listening effort would reveal even greater differences between CHL and CNH. This is an important finding given the potentially significant negative effects of fatigue on school-age children.

Although the causes of fatigue can vary, it is often associated with sustained mental effort (Ahsberg, Gamberale, & Gustafsson, 2000; Hornsby, 2013; Lieberman, 2007). Relevant for CHL, qualitative interviews and survey data suggest that working adults with hearing loss feel the need to sustain attention, concentration, and effort to compensate for work-related hearing difficulties. An important consequence of this additional mental effort is an increase in stress and tension associated with fatigue (Grimby and Ringdahl, 2000; Hétu, Riverin, Lalande, Getty, & St-Cyr, 1988). Our findings suggest that CHL may experience similar outcomes. The impact of this increased fatigue is significant for adults. For example, using questionnaires, Kramer and colleagues (Kramer, Kapteyn, & Houtgast, 2006; Nachtegaal et al., 2009) found that working adults with hearing loss required more “effort in hearing” than peers without hearing loss doing similar, or the same, jobs. This extra effort was associated with an increased rate of sick leave due to complaints of fatigue, strain, and burnout, and the need for a longer time to recover from hearing-related stress and strain at work. We can speculate that there is a similar impact in CHL at school.

Further, these subjective ratings in CHL highlight a potential link between increased cognitive processing demands resulting from degraded hearing and fatigue. Recent empirical studies offer support to the idea that, like adults, CHL must increase their mental effort to overcome deficits associated with their hearing loss (Choi, Lotto, Lewis, Hoover, & Stelmachowicz, 2008; Hicks & Tharpe, 2002; Pittman, 2011), potentially increasing their risk for subsequent fatigue. The potential impact of increased listening effort, stress, and fatigue on children is important because these factors could compromise a child's facility to learn in a noisy classroom environment (Hicks & Tharpe, 2002; Pittman, 2011). Fatigue is associated with a decreased ability to maintain attention and concentration, slower mental processing, and impaired decision making (Bryant, Chiaravalloti, & DeLuca, 2004; van der Linden, Frese, & Meijman, 2003). Recent psychophysical work in adults supports a connection between increased cognitive processing demands when listening to speech in noise and fatigue-related changes in cognitive processing ability. Hornsby (2013) measured cognitive processing speed (time to respond to a visual stimulus) in adults with hearing loss while they completed a sustained (~50 min) cognitively demanding speech dual task. When testing was conducted without hearing aids, processing speed decreased systematically over time, an objective indication of fatigue. However, processing speed remained stable during the same task when participants wore their hearing aids, highlighting the potential benefits of amplification for reducing fatigue effects.

Given the impact of fatigue on cognitive processing, it is not surprising that recurrent fatigue is associated with reduced academic performance in school-age children (Nagane, 2004; Ravid et al., 2009a, 2009b; Stoff et al., 1989). For example, Nagane (2004) used a self-report measure to assess fatigue in fourth grade students recruited from typical, public school classrooms. Children reporting higher levels of fatigue were less active in school and performed more poorly on standardized reading comprehension and math tests. Ravid et al. (2009a, 2009b) found that fatigue resulting from poor sleep patterns was a significant predictor of reduced readiness for academic advancement in typically developing preschool and kindergarten children. Given the well-documented negative effects of hearing loss on academic performance (Bess et al., 1998; Moeller, 2007; Most, 2004, 2006; Wake, Hughes, Hughes, Collins, & Rickards, 2004), CHL suffering from fatigue appear to be at even greater risk for academic difficulties. In summary, this study provides preliminary evidence that CHL, compared to peers with normal hearing, are at increased risk for fatigue and its significant negative consequences.

Limitations and Future Directions

These results are based on preliminary data from 10 CNH and 10 CHL that were collected as part of a larger, ongoing study. It is clear that additional data are needed to confirm and extend these findings. Despite the relatively small number of participants, significant differences in fatigue ratings were observed between CHL and CNH. However, substantial variability was also present, particularly in the CHL. This is consistent with our belief that fatigue is a multidimensional construct modulated by many factors, including hearing loss. Unfortunately, there is a paucity of research in this area, particularly in children, and data related to the mechanisms responsible for this increased risk of fatigue are limited. The purpose of this preliminary work, however, was to first determine if ratings of fatigue, obtained using a standardized measure, differed between CHL and age-matched CNH. Thus, factors in addition to hearing loss that may have impacted the group differences seen in this study remain unknown.

Several factors could have impacted the ratings of fatigue reported by the CHL. Our CHL and CNH groups were matched in terms of age, and all had typical nonverbal intelligence and were monolingual English speakers. However, the CHL and CNH had very different language abilities. Likewise, the CHL varied in many ways such as degree of hearing loss, age at amplification or implantation, amplification type, hearing age, and communication mode. Other unknown factors such as communication demands and common environmental conditions (e.g., presence and magnitude of background noise and reverberation present during normal daily activities) may also have varied among the CHL and between groups. Thus, additional research is required to improve our understanding of the underlying factors responsible for the fatigue observed in CHL. In addition, now that it is clear that CHL report significantly higher levels of fatigue, more detailed studies of the association between fatigue and academic performance in these children are warranted. Moreover, additional research is needed to (a) replicate these findings in a larger sample of CHL, (b) extend these preliminary data to the various subtypes of CHL, (c) improve our understanding of the specific factors responsible for these differences, and (d) further explore the impact of fatigue on related skills, such as academic learning.

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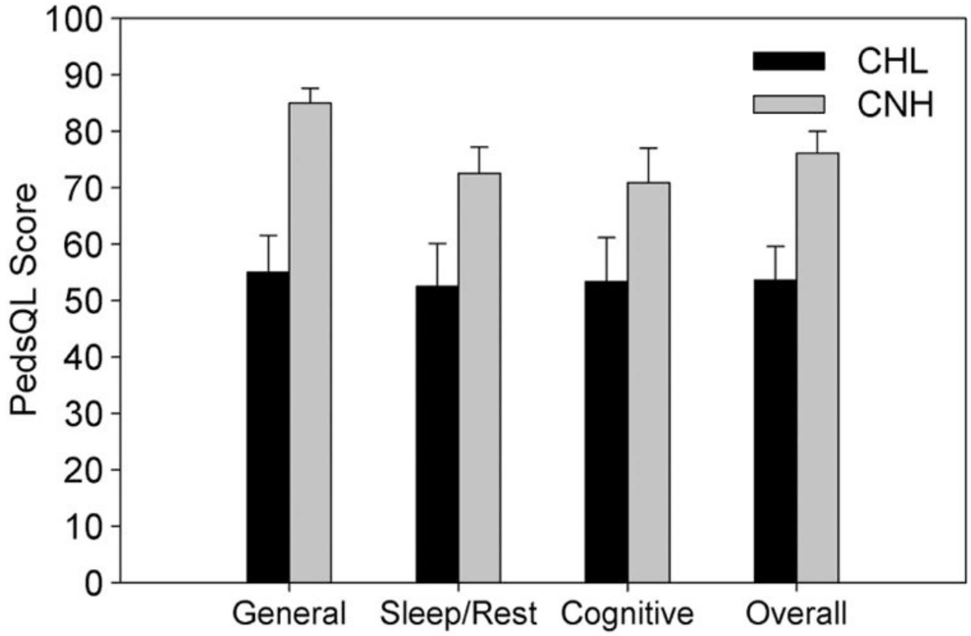

Figure 1.

Mean Pediatric Quality of Life Inventory Multidimensional Fatigue Scale (PedsQL MFS) subscale and overall fatigue scores from children with hearing loss (CHL) and children with normal hearing (CNH). Lower values reflect more fatigue. Error bars = 1 standard error.

Table 1

Characteristics of children with hearing loss (CHL), including unaided thresholds (in dB HL)

						Frequency (in Hz)							
S	**Age**	**Amp. Age**	**Hearing Age**	**Amp. Type**	**Ear**	**250**	**500**	**1000**	**2000**	**3000**	**4000**	**6000**	**8000**
1	75	50	25	NA	L	70	85	95	105	120	115	120	100
				CI	R	95	100	110	115	120	120	120	100
2	84	22	62	HA	L	85	85	90	80	75	70	85	85
				CI	R	95	105	115	100	100	90	105	100
3	87	77	10	NA	L	5	15	20	15	5	15	25	15
				HA	R	40	50	55	60	30	35	65	55
4	127	24	103	HA	L	30	35	40	40	40	40	40	45
				HA	R	30	30	50	50	40	45	45	45
5	129	18	111	HA	L	35	40	55	50	45	45	40	45
				HA	R	45	45	60	55	50	40	50	30
6	140	84	56	NA	L	70	65	75	90	105	110	105	90
				HA	R	35	25	25	35	35	25	45	55
7	142	108	34	HA	L	25	25	25	15	50	60	65	60
				HA	R	25	20	20	20	50	60	65	60
8	143	132	11	HA	L	10	15	10	45	50	50	45	40
				HA	R	5	5	0	25	45	50	40	40
9	153	30	123	CI	L	75	120	120	120	120	120	120	120
				CI	R	100	120	120	120	120	120	120	120
10	153	30	123	CI	L	90	120	120	120	120	120	120	120
				CI	R	95	110	120	120	120	120	120	120

Note. S = subject; Amp. Age = age at amplification; Amp. Type = type of amplification; HA = hearing aid; CI = cochlear implant; NA = no amplification on that ear; L = left ear; R = right ear. Age, age at amplification, and hearing age are reported in months.