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The frequency of vestibular disorders in developmentally delayed preschoolers with otitis media.

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The Frequency of Vestibular Disorders in Developmentally Delayed Preschoolers with Otitis Media

(middle ear functioning, occupational therapy, pediatrics, sensory integration)

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This study investigated the frequency of vestibular disorders in developmentally disabled preschoolers who did and who did not have a history of otitis media. Fifteen children with a history of otitis media and fifteen children with no history of otitis media were given two tests for vestibular functioning: the Southern California Postrotary Nystagmus Test (SCPNT) and the Lateral Labyrinthine Righting Reaction (LLRR), acting on the head. The scores on these tests were dichotomized, and a correlation between these two tests as measures of vestibular function was obtained. Because this correlation did not reach a satisfactory level, two a satisfactory level, two separate chi-square analyses were performed to examine the frequency of vestibular disorders with otitis media. Both tests showed a statistically significant difference in the incidence of vestibular disorders between the two groups of children; the group having otitis media demonstrated more vestibular disorders. The SCPNT demonstrated more striking results than did LLRR. This finding is related to the two tests measuring different aspects of vestibular functioning; the separate chi-square analyses were performed to examine the frequency of vestibular disorders with otitis media. Both tests showed a statistically significant difference in the incidence of vestibular disorders between the two groups of children; the group having otitis media demonstrated more vestibular disorders. The SCPNT demonstrated more striking results than did LLRR. This finding is related to the two tests measuring different aspects of vestibular functioning; the SCPNT reflects semicircular canal functioning, and the LLRR reflects utricular and saccular functioning. The criteria used for LLRR (four seconds) also may have influenced the results obtained using this test.

Occupational therapists and other professionals involved with developmentally and learning disabled children have clinically recognized the common occurrence of otitis media in conjunction with children diagnosed as having vestibular disorders (1, 2). As the vestibular system becomes more widely recognized as a major contributor to normal development, the interest in disturbances of this system also continues to grow. Additionally, the potential effect of otitis media on the vestibular apparatus has been a growing area of concern and research (3).

The role of the vestibular system in motor development, specifically equilibrium, muscle tonus, and oculo-motor control, has been documented by several leaders in the field of neurophysiology and neuroanatomy (4, 5). An association between vestibular and learning difficulties has been reported by

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Ayres (6), Levinson (2), and deQuiros (7). Middle ear infections, or otitis media, have been noted as occurring in conjunction with or resulting in vestibular disturbances.

Several authors (8, 9) have alluded to the possible relationship between otitis media and vestibular disorders. Levinson (2) has even postulated a cause and effect relationship. Certainly, the anatomical relationship between these two systems cannot be overlooked because otitis media affects the middle ear, which is in close proximity to the inner ear, where the labyrinth (vestibular apparatus) is housed. This close relationship raises the question of the potential effects of otitis media on the labyrinths and consequently the vestibular system. However, few studies have investigated solely the potential relationship between otitis media and vestibular disorders. In particular, no studies have focused on the developmentally disabled child who is particularly susceptible to middle ear infections and is often found to have vestibular-related disorders.

Literature Review

Otitis media is one of the most common childhood illnesses (10, 11). Kessner, Snow, and Singer (12) suggest that 30% of all children between 6 months and 3 years old have evidence of middle ear disease. These high percentages were further verified by Howie (13) and Dobbie and Charles (14).

The high incidence of otitis media has led to many investigations of the long-term effects of chronic middle ear infections. It has been noted in the literature that otitis media may often exist undetected because of a lack of overt symptoms, which often results in a low-grade, long-term infection and further complications (15). Symptoms of otitis media may include a buildup and discharge of fluid from the middle ear, a low-grade fever, gradual hearing loss, and, in more advanced cases, vertigo, deafness, nausea, and loss of equilibrium (5, 10, 16).

The anatomical relationship of the middle and the inner ear and potential pathways for spread of infection have been discussed by several authors. Goycollea, Paparella, Juhn, and Carpentar (3) did a longitudinal study of the oval and round windows as potential pathways for the spread of infection from the middle ear into the inner ear where the labyrinthine apparatus may be affected. These researchers suggest that noxious elements pass through the round window membrane and cause inner ear pathological changes. A case study of Suga and Lindsay (17) supports these findings.

The anatomical relationship between middle ear infections and labyrinthine disorders has also been documented by Baloh and Honrubia (5), who state, "Infection from acute suppurative labyrinthitis usually has its origin in the middle ear or in cerebro-spinal fluid" (p 174). These researchers also propose that the round window is the pathway for spread of infection from middle to inner ear, eroding through bony wall and the round window.

Several authors (18, 19) have investigated whether the effect of potential hearing loss associated with otitis media is related to cognitive and language development. Menyuk (20) speculates that a permanent hearing loss is detrimental to cognitive and linguistic development along with academic achievement. A fluctuating or minimal loss may be as detrimental but may result in delays in learning and language. He states that children who suffer early and frequent episodes of otitis media may have delayed acquisition of basic language and cognitive development but may have the potential to catch up. The lack of readiness or the delay in academic achievement noted in the population of children with recurrent or chronic otitis media may be related to a fluctuating or minimal hearing loss. Rapin (15) and Katz (21) also share Menyuk's (20) speculations.

The physiological and anatomical changes that occur at the level of the brain stem because of auditory deprivation associated with otitis media are discussed by Katz (21). He states, "Not only can sensory deprivation disrupt the function of a mature organ but it also can adversely affect the anatomical development of nerve cells when stimulation is restricted during early life" (p 879).

In line with Katz's (21) theory, several authors believe there's a relationship between otitis media and learning difficulties. Zinkus et al. (22) found that children with chronic and severe otitis media had substantial delays in speech and language development, auditory processing, reading, and spelling. He suggests early medical intervention in cases of chronic serous otitis media to prevent the development of specific learning disabilities. Evidence linking middle ear infections to learning difficulty is also cited by Ventry (23). However, he states that there is conflicting evidence that auditory deprivation is responsible for the difficulty.

The possibility that factors other than auditory deprivation are involved in learning disorders and otitis media is alluded to by Masters and Marsh (8). Their research rec-

ognizes vestibular disorders as a possible sequel to otitis media and as a contributing factor in learning disabilities. As the vestibular system becomes increasingly recognized as a possible etiological factor in learning disabilities (24, 6, 2), potential relationships beteen otitis media and vestibular disorders have been postulated (2, 8). Levinson (2) hypothesizes that otitis media may affect the vestibular proprioceptive system, which in turn may be a factor in dyslexia. He states, "The incidence of specific location on cerebellar-vestibular dysfunction underlying dysmetric dyslexia suggests the etiological possibility that 'harmless' ear infections during childhood may result in, or intensify, dysfunctioning within the labyrinthine-vestibular-cerebellar circuitry" (p 96).

Price and Teachman (1) also clinically noted a potential relationship between middle ear infections and vestibular functioning. Two of their subjects had changes in vestibular-related behaviors and postrotary nystagmus scores. In these cases, and in three others, the children with otitis media and upper-respiratory congestion had an increased sensitivity to vestibular stimulation in that they could not tolerate rotary or lateral motion, although they initially craved and enjoyed such stimulation. Reduction in postrotary nystagmus scores was also documented during these periods in two cases. Price and Teachman feel that upper-respiratory congestion and otitis media may affect vestibular functioning, as evidenced by increased hypersensitivity to motion with a tendency toward decreased postrotary nystagmus scores.

Research in this area of vestibular disorders and otitis media is relatively new and sparse. Disorders of the labyrinth as a long-term complication of otitis media and the potential relationship between otitis media and learning disorders is still not clear, but beginning evidence seems to support such an association. The purpose of this study was to investigate the frequency of vestibular disorders in developmentally disabled preschoolers who had otitis media.

The major thrust of the study was to verify the difference in the incidence of vestibular disorders in developmentally disabled preschoolers who had history of otitis media and those who did not.

Methods

Subjects

Thirty preschool children who were enrolled in or being evaluated by a local preschool program were selected as subjects. Each subject had to be 3.5 to 5.5 years old and be labeled as developmentally disabled by certified school psychologists. Developmentally disabled was defined according to the *Federal Register* (29) as,

> A disability of a person which (i) is attributable to mental retardation, cerebral palsy, epilepsy, or autism; (ii) is attributable to any other condition of a person found to be related to mental retardation because such conditions result in similar impairment of intellectual functioning or adaptive behavior . . .; (iii) or is attributable to dyslexia resulting in a disability described in paragraph (i) or (ii); iv originates before such a person attains eighteen; (v) has continued indefinitely; or (vi) constitutes a substantial handicap to such persons' ability to function normally in society.

Fifteen of the subjects met the criteria for having otitis media, that is, they had four or more episodes of otitis media in their past history, with one episode within the last calendar year (April 1981–April 1982). Fifteen of the subjects met the criteria for not having otitis media, that is, they had no past history of otitis media and no episodes within the last calendar year.

To determine which children had otitis media, audiology, ENT (ear, nose, and throat), physicians', and parents' reports were reviewed, in addition to any other records contained in the subjects' charts that pertained to middle ear infections.

Test Instruments

Vestibular disorders were determined by using the Southern California Postrotary Nystagmus Test (SCPNT) and the Lateral Labyrinthine Righting Reaction, acting on the head (LLRR). Two test instruments were used to evaluate vestibular disorders because this ensured stronger indications of overall vestibular functioning (i.e., utricular and saccular, as well as semicircular canal functions).

Choosing tests of vestibular functioning for preschool children presents several difficulties: the availability of standardized tests for the preschool age group is limited and several standard clinical and neurological tests (prone-extension; standing balance, eyes closed; and Rhomberg) may be impractical. After reviewing the literature on acceptable tests, the SCPNT and the LLRR seemed the most appropriate and accurate measures. No other standardized tests or clinical observations of vestibular functioning were available at the time of this study.

The LLRR has been cited as an indicator of vestibular functioning, specifically of the utricle and saccule (25). Physiologically, a lateral tilt of the head is known to stimulate the otoliths in the saccular and utricular macules of the vestibular

apparatus. This initiates reflexes that cause contraction of muscles opposing the force acting on the head and thus equilibrium is maintained. Specifically, in lateral labyrinthine righting, left lateral displacement of the head should cause an immediate contraction of muscles on the right side of the body and the head should return at once to the midline position.

The SCPNT is a well-documented and accepted indicator of function of the vestibular-ocular reflex activated by the horizontal semicircular canals (26). Ayres (26, 27) suggests that the evaluation of nystagmus using the SCPNT may be useful in determining vestibular disorders and in differentiating between specific types of dysfunction in learning-disabled children.

Rotation of the head (angular acceleration) causes initial endolymphatic flow, which displaces the cupula of the horizontal semicircular canal. Eye movements to the opposite side of rotation occur as a reflex to maintain visual fixation (5). When rotation suddenly stops, endolymphatic flow is in the direction of the rotation, and eye movements to the same side occur with an intermittent flick to the opposite side. This is known as postrotary nystagmus.

Test Procedures

Testing consisted of a 15-minute individual testing session with the examiner in a distraction-free room at each child's respective school. The LLRR was given first and was followed by the SCPNT. The SCPNT was given second because it is potentially disruptive to the child. Also, the SCPNT provides vestibular stimulation, which may affect the LLRR response. Both tests were administered and scored according to their standardized procedures. For the SCPNT, the norms published by Punwar (28) were used because they are standardized for 3- and 4-year-old children.

Results

Test data from 30 developmentally disabled preschool children were used to determine the incidence of vestibular disorders in the two groups of children. The data from each test were dichotomized, and each subject was categorized as either having or not having a vestibular disorder. For the SCPNT, raw scores were converted to standard scores according to the norms published in the SCPNT manual (26). These norms were used for the 3- to 5-year-old children because Punwar (28) found the norms to be valid for this age group. Standard scores falling below .9 (−1.0 to −2.2) were given a "1," which indicated a vestibular disorder; those of −.09 or above were given a dichotomized score of "0," which indicated no vestibular disorder. No prolonged postrotary nystagmus occurred. LLRR raw scores were also dichotomized. The combined scores of four seconds or below were given a "0," which indicated no vestibular disorder; scores four seconds and above received a "1," which indicated there was vestibular disorder. Dichotomized and raw scores for each subject on both SCPNT and LLRR are given in Table 1. Before the data were analyzed, a phi correlation between the SCPNT and the LLRR was calculated to determine whether these two tests were highly correlated measures of vestibular functioning. The phi coefficient as shown in Table 2 was .505. Although this correlation is significant, it is considered only moderately high, and therefore it was concluded that these two tests were independent measures of vestibular functions for the purposes of this study. Because of this, separate chi-squares were performed on each test rather than one chi-square on a single composite score of both tests (see Tables 3 and 4).

A chi-square analysis using the SCPNT as a measure of the incidence of vestibular disorders between subjects who did and did not have otitis media was performed. Dichotomized scores for SCPNT were used, and the presence or absence of otitis media was treated as a dichotomized variable. The chi-square analysis, as shown in Table 3, illustrates that there is a difference in the incidence of vestibular disorders between groups of subjects. A corrected chi-square with 1 df equals 6.806, which is significant at the .0091 level.

A similar chi-square analysis was used with the LLRR to differentiate subjects who did and did not have otitis media. Dichotomized scores for LLRR and otitis media were used. A difference in the incidence of vestibular disorders between groups of children who did and did not have otitis media was found with the chi-square analysis ($\chi^2_{(1)} = 4.261$, $p = .0390$) as illustrated in Table 4, chi-square on LLRR by otitis media.

Also, an analysis of variance on raw SCPNT and LLRR scores was performed to determine whether there were differences between subjects who had otitis media and those who did not. Results showed a significant difference between scores on the SCPNT for both types of subjects. The F ratio for the factor representing presence or absence of otitis media was significant [$F(1,28) = 12.55$, $p = .004$]. However, there was no difference between scores on the LLRR. The F ratio was not significant [$F(1,28) = 2.216$, $p = .476$].

Discussion and Conclusions

The results of the chi-square analysis indicate that there was a significant difference in the incidence of vestibular disorders between developmentally disabled preschoolers who did and who did not have a history of otitis media. Both the SCPNT and the LLRR tests demonstrated this difference, although the SCPNT results were

Table 1
Raw and Dichotomized Data for SCPNT and LLRR

No.	Otitis Media Present	Raw, sec	SCPNT Scores		LLR Scores	
			SD	Dichotomized	Raw, sec	Dichotomized
1	Yes	18	0.0	0	0	0
2	Yes	9	−1.5	1	7	1
3	Yes	16	−0.6	0	5	0
4	Yes	15	−0.7	0	0	0
5	Yes	8	−1.6	1	6	1
6	Yes	15	−0.7	0	0	0
7	Yes	6	−1.9	1	3	0
8	Yes	12	−1.1	1	0	0
9	Yes	19	+0.2	0	7	1
10	Yes	5	−2.1	1	0	0
11	Yes	9	−1.5	1	9	1
12	Yes	5	−2.1	1	9	1
13	Yes	8	−1.6	1	5	1
14	Yes	9	−1.4	1	2	0
15	Yes	11	−1.2	1	2	1
16	No	21	+0.1	0	0	0
17	No	24	+0.5	0	0	0
18	No	14	−0.6	0	1	0
19	No	16	−0.6	0	3	0
20	No	18	−0.3	0	4	0
21	No	18	−.03	0	2	0
22	No	19	−0.1	0	4	0
23	No	14	−0.8	0	3	0
24	No	15	−0.7	0	3	0
25	No	6	−1.9	0	3	0
26	No	26	+0.8	0	4	0
27	No	25	+0.7	0	3	0
28	No	14	−0.6	0	2	0
29	No	11	−1.2	1	7	1
30	No	24	+0.5	0	3	0

SCPNT, Southern California Postrotary Nystagmus Test; LLRR, Lateral Labyrinthine Righting Reaction, acting on the head.

Table 2
Phi Correlation of SCPNT and LLRR

	LRRR	
	Without Vestibular Disorder	With Vestibular Disorder	
	16	2	18
	5	7	12
	21	9	

Phi = .50483.

more striking than those of the LLRR, with significance levels of .0091 and .0390, respectively. These findings support Levinson's (2) theory regarding a connection between chronic middle ear infections and potential vestibular disorders and suggest a possible relationship beteen these two in developmentally disabled preschoolers.

Although the phi correlation between the two tests was significant (.505), it was not considered high enough to regard these tests as interrelated measures of vestibular functioning (A. Sockloff, PhD, Professor of Statistics, Temple University, Philadelphia, PA, personal communication, May 1982). This is partially because the two tests measure two different aspects of the vestibular system: the SCPNT reflects semicircular canal function and the LLRR reflects utricle and saccule function (2, J Kimball, PhD, OTR, Director of Occupational Therapy, University of New England, Biddeford, ME, personal communication, January 1983). However, the correlation between the tests was significant, which supports an initial prediction that both tests together are a sufficient measure of overall vestibular functioning.

Using the chi-square analysis, however, it did not yield significant differences in an analysis of variance between the subjects who have or did not have otitis media. Therefore, it is difficult to make statements when using the LLRR as an indicator of vestibular functioning; however, the LLRR chi-square analysis lends support to the conclusion regarding differences in vestibular functioning between subjects. The SCPNT seems to be a good discriminator of vestibular functioning because the comparison of scores for this test between groups showed highly significant differences.

The overall results of this study seem to suggest a significant incidence of vestibular disorders in developmentally disabled preschoolers who have a history of otitis media. Although this relationship warrants further investigation with more sophisticated testing and sampling procedures, those involved with this population about the potential relationship between inner and middle ear function should be cautioned. Routine screening of vestibular functioning for preschoolers having a history of chronic otitis media may be suggested.

Occupational therapists and other professionals need to be aware of the potential relationship between middle and inner ear pathology. Although further research in this area is necessary to verify and expand these results, there are several implications for occupational therapy. Children with chronic otitis media who exhibit developmental delays should be referred to occupational therapy for appropriate vestibular screening. Children who are presently seen in occupational therapy and develop acute episodes of otitis media should be monitored for changes in vestibular functioning. Additionally, a thorough history regarding middle ear health and functioning should be part of the ongoing occupational therapy record because it may yield information regarding past and present vestibular functioning.

Table 3
Chi-Square on SCPNT (as a Measure of Vestibular Disorders) by Otitis Media

	SCPNT		
	Without Otitis Media	With Otitis Media	
Without vestibular disorder	13	5	18
With vestibular disorder	2	10	12

Corrected $\chi^2_{(1)} = 6.806$, significance = .0091.

Table 4
Chi-Square on LLRR (as a Measure of Vestibular Disorders) by Otitis Media

	LLRR		
	Without Otitis Media	With Otitis Media	
Without vestibular disorder	14	8	22
With vestibular disorder	1	7	8

Corrected $\chi^2_{(1)} = 4.26$, significance = .0390.

Further research in this area is necessary to verify these results. Replication of this study using the same as well as other populations, including learning-disabled and normal preschool children, is recommended.

Summary

This study investigated the frequency of vestibular disorders in developmentally delayed preschoolers who did or did not have a history of otitis media. The children with a history of otitis media were found to have a significantly higher incidence of vestibular disorders than those without such a history. Both the SCPNT and the LLRR tests demonstrated these results. There were, however, slight differences between the tests. This was in part attributed to the fact that these two tests measure different areas of the vestibular system: the SCPNT measures semicircular canal function and the LLRR measures utricular and saccular function. This paper discusses the implications of these findings for occupational therapy and gives suggestions for further research.

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