The purpose of this study was to investigate the nystagmus response in school-age children with Down's syndrome. The 35 subjects were between 5 and 9 years of age and were enrolled in public school programs for the educable and trainable mentally retarded in the northern metropolitan areas of Utah. The Southern California Postrotary Nystagmus Test (SCPNT) was administered with slightly modified verbal instructions. Durations of nystagmus for the subjects with Down's syndrome were compared with Ayres' normative data from the SCPNT using a t-test for two independent means. Results indicated there was a significant reduction in the duration of nystagmus in the children with Down's syndrome when compared to Ayres' sample of normal children; however, there was no significant difference between males and females with Down's syndrome in duration of postrotary nystagmus.
The importance of the relationship between the functions of the vestibular system and human development has received some attention from investigators in recent years (1-4). A number of studies have demonstrated that the vestibular system contributes to the development of muscle tone and motor skills, language acquisition, and academic learning (5-19). Nystagmus (an eye reflex) is one indicator of vestibular function because of its association with the vestibular mechanism. Nystagmus can be assessed by electronystagmograph, the caloric, and rotary tests. Several investigations (7, 16, 20) have focused on the postrotary nystagmus responses of delayed or disabled children. Ayres (7) found reduced nystagmus in 50 percent of the learning-disabled children who exhibited sensory integrative dysfunction. She suggested that, in some children, the reduced postrotary nystagmus may be due to an insufficient quantity of vestibular stimuli reaching their natural destinations. Thus the contribution to sensory integrative processes is minimized. Ayres also hypothesized that over-inhibition of the vestibular nuclei from the cerebellum may be a factor that contributes to nystagmus reduction.

Rendle-Short (16) compared the postrotary nystagmus responses of normal children and those with minor neurological impairment. They found that mean duration of postrotary nystagmus was higher in the normal population (x = 15.6 seconds) than in the children with neurological impairment (x = 3.7 seconds). Ritvo, Ornitz, Eviatar, Markham, Brown, and Manson (20) found a significant decrease in the postrotary nystagmus responses of autistic children in a lighted room. They suggested that there may be developmental lags in the vestibular organs or a difference in the arousal mechanism of this population.

One population that has received little attention in the research associated with vestibular function is children with Down’s syndrome. This population exhibits hypotonia, as well as delays in gross motor skills, language development, and academic learning (21-26). These characteristics suggest the possibility of vestibular dysfunction. In reviewing the literature, the authors were able to locate only one study focusing on Down’s syndrome and nystagmus responses. Kantner, Clark, Allen, and Chase (12) studied motor improvement and postrotary nystagmus responses in infants with Down’s syndrome.

The experimental group, which comprised two normal infants and two infants with Down’s syndrome, were provided with ten treatments of specific vestibular stimulation. The control group, comprising one normal infant and two infants with Down’s syndrome, did not receive treatment. Results indicated that subjects in the experimental group exhibited more improvement on reflex testing when compared with the control sample. Before the vestibular stimulation treatment, the children with Down’s syndrome exhibited prolonged postrotary nystagmus. Kantner, et al. postulated that the prolonged nystagmus indicated vestibular hyperactivity resulting from failure in maturation of an inhibitory circuit in the central nervous system. After treatments of vestibular stimulation, the postrotary nystagmus declined in both normal children and children with Down’s syndrome. It should be noted, however, that the sample in this study was small and the subjects were 6 to 24 months of age. Consequently, these results cannot be generalized to school-age children with Down’s syndrome.

The purpose of the present investigation was to assess postrotary nystagmus in school-age children with Down’s syndrome and determine if any significant difference existed between their performance and the performance of the sample of normal children on which the Southern California Postrotary Nystagmus Test (SCPNT) was standardized (27). Whether or not there were sex differences in nystagmus responses of the sample with Down’s syndrome was also investigated. The following hypotheses were formulated: 1. that there would be a significant difference in the duration of postrotary nystagmus (as measured by the SCPNT) between children with Down’s syndrome and Ayres’ sample of normal children; 2. that there would be no significant difference between the duration of postrotary nystagmus of boys and girls within the population with Down’s syndrome.

The limitations of this study relate primarily to the use of the SCPNT as a measure of vestibular functioning. The SCPNT has been criticized as being less reliable than the caloric testing or electronystagmograph (ENG) in assessing prob-
Table 1

Number (No.) of Subjects (S), Means (X), and Standard Deviations (SD) Are Recorded in Seconds of Nystagmus Duration following Rotation to S's Left (L), and Right (R), and Total of Left and Right Scores by Age and by Sex

<table>
<thead>
<tr>
<th>Age (Yr)</th>
<th>5.0 - 5.11</th>
<th>6.0 - 6.11</th>
<th>7.0 - 7.11</th>
<th>8.0 - 8.11</th>
<th>9.0 - 9.11</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>F</td>
<td>Combined</td>
<td>M</td>
<td>F</td>
</tr>
<tr>
<td>No. of S</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>4</td>
<td>6</td>
<td>5</td>
<td>4</td>
</tr>
<tr>
<td>X to L</td>
<td>11.0</td>
<td>6.3</td>
<td>7.8</td>
<td>4.2</td>
<td>9.8</td>
</tr>
<tr>
<td>SD to L</td>
<td>1.0</td>
<td>2.3</td>
<td>3.6</td>
<td>3.6</td>
<td>3.4</td>
</tr>
<tr>
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<td>5.0</td>
<td>8.5</td>
<td>4.8</td>
<td>9.3</td>
</tr>
<tr>
<td>SD to R</td>
<td>4.5</td>
<td>1.0</td>
<td>5.8</td>
<td>3.1</td>
<td>2.4</td>
</tr>
<tr>
<td>X of total</td>
<td>26.5</td>
<td>11.3</td>
<td>16.3</td>
<td>9.0</td>
<td>19.0</td>
</tr>
<tr>
<td>SD of total</td>
<td>5.9</td>
<td>4.2</td>
<td>8.9</td>
<td>6.8</td>
<td>5.8</td>
</tr>
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</table>

lems in the vestibular mechanism; however, several studies have indicated that the SCPNT can provide reliable information and that the use of inexpensive equipment as well as the short time required for testing make it very appropriate for use (28, 29).

Method

Subjects. Fifty-five (55) children with Down's syndrome, ages 5 through 9 years, were recruited from school districts in northern metropolitan areas of Utah. All children were enrolled in public school programs for the educable or trainable mentally retarded. Permission letters and questionnaires were sent to parents of the identified subjects. Eventually, 20 children were excluded from the investigation for a number of medical reasons (i.e., heart disorders, visual impairment, seizure disorders) or a lack of parent consent. The final sample consisted of 17 males and 18 females who were all from white middle-class families. The males ranged in age from 5 years 6 months to 9 years 11 months (mean = 7 years 6 months). The females ranged in age from 5 years 6 months to 9 years 10 months (mean = 7 years 4 months). Of the 35 children, 5 were enrolled in programs for the educable mentally retarded and the other 30 were in programs for the trainable mentally retarded. The data on normal subjects were obtained from the sample used to standardize the SCPNT (27) — 115 males and 115 females from Southern California and ranging in age from 5 to 9 years.

Procedure. A pilot study was conducted on ten children with Down's syndrome to assess whether or not they fully understood the directions for the administration of the SCPNT. Eight of these children failed to follow specific verbal directions: for example, sit on the board like an Indian. Look at the wall. Don't look at me. In addition, some children tended to close their eyes when abruptly stopped. Based upon this information, the following modifications in administration for the SCPNT. Eight of these children failed to follow specific verbal directions: for example, sit on the board like an Indian. Look at the wall. Don't look at me. In addition, some children tended to close their eyes when abruptly stopped. Based upon this information, the following modifications in administration were made for the actual investigation. First, children were told to get into a cross-legged position and hold the board with their hands. If necessary, children were manually helped into this position. Second, as a means of explaining the concept turning, the children were rotated slowly (3 seconds) to the side they were going to be turned. Third, after the examiner had given verbal and gestural instructions regarding which wall was to be looked at following the abrupt stop, the children were asked to point to the appropriate wall. Following the abrupt stop, the examiner lightly touched the children's chin to direct their heads toward the proper wall while giving the verbal direction. The children were also reminded to keep their eyes "big" to assist them in keeping them open.

For the actual study, the SCPNT as modified above was used to determine the duration of postrotary nystagmus. All tests were administered between 8:00 a.m. and 2:00 p.m. and at least 1 hour after meals to avoid unnecessary nausea. Also, the subjects were not allowed to participate in gross motor activities that provided extravesicular stimulation (i.e., running, spinning, jumping, swinging) 1 hour
before testing. Such extratestibular stimulation was minimized so that a more accurate picture of the subjects' nystagmus responses would be obtained. The test was given by an occupational therapist certified in its administration in a lighted, quiet room within the children's school.

The procedures for the administration of the SCPNT were as follows. The child was asked to sit on the standardized postrotary nystagmus board in a cross-legged fashion. Verbal or physical assistance was provided if needed. The child was then given the standardized instructions with the exception of the previously mentioned modifications. His head was placed in a 30-degree forward position (measured with an angle guide) so that the semicircular canals were positioned in the horizontal plane. The child was rotated 10 times in 20 seconds, first to the left, then to the right. An interval of at least 60 seconds was provided to allow the child time to express reactions toward the stimulation. At this time the examiner also recorded observations regarding the child's head and trunk balance.

The test was considered invalid if the child reacted in any way that prevented the examiner from observing the actual postrotary nystagmus. The examiner looked for such factors as failure to keep eyes open or focusing on a specific object instead of looking at a blank wall. A position change of more than 15 degrees for the head was also considered invalid. When the child's head was flexed 30 degrees from vertical, the horizontal semicircular canals were approximately positioned in the plane that would produce horizontal nystagmus when stimulated. Test-retest reliability was performed by the same therapist at least 1 week after the initial test and without the results of the last test on hand.

Results

Durations (seconds) of postrotary nystagmus were compiled for each direction rotated and for the total of both directions. Mean and standard deviations were obtained for each age category by age and sex. Table 1 summarizes the average number of seconds of nystagmus and standard deviations following rotation to the left, the right, and the total of these scores by age and sex. Data are also given for both sexes combined.

Mean scores for the total sample with Down's syndrome were computed and are reported in Table 2 together with the normative data from the SCPNT. An independent t-test (30) was used to compare the differences between the total combined scores of the Down's syndrome and the normative data. A significant difference ($t = 3.25, p < .01$) was noted. The difference between total mean scores of males and females with Down's syndrome was not statistically significant at the .05 level using a two-tail t-test for independent means.

Reliability of measurement was obtained by computing a t-test for correlated samples between two tests given at least 1 week apart to 15 subjects. No significant difference was found ($t = .143, p > .05$). Data analysis with the Pearson product-moment correlation indicated acceptable test-retest reliability ($r = .88$).

Clinical observations of the responses of the subjects to the SCPNT were recorded and analyzed. Twenty-nine subjects had a measurable reaction. Six subjects expressed neutral reactions, but did not refuse the test. Only 3 of the 35 subjects exhibited an alarm reaction to the testing. During rotation 20 subjects were able to maintain total body balance and the other 15 demonstrated a slight loss of balance. However, upon abrupt stop, 3 subjects were able to maintain steady balance, 26 subjects exhibited slight loss of balance, 3 lost balance but regained it, and the other 3 lost balance and fell into the examiner's

<table>
<thead>
<tr>
<th>Sample</th>
<th>Down's Syndrome</th>
<th>Normal*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>F</td>
</tr>
<tr>
<td>No. of S</td>
<td>17.0</td>
<td>18.0</td>
</tr>
<tr>
<td>X of L</td>
<td>6.9</td>
<td>7.8</td>
</tr>
<tr>
<td>SD to L</td>
<td>3.3</td>
<td>2.7</td>
</tr>
<tr>
<td>X to R</td>
<td>8.2</td>
<td>7.1</td>
</tr>
<tr>
<td>SD to R</td>
<td>4.4</td>
<td>2.4</td>
</tr>
<tr>
<td>X of total</td>
<td>15.1</td>
<td>15.0</td>
</tr>
<tr>
<td>SD of total</td>
<td>7.4</td>
<td>5.0</td>
</tr>
</tbody>
</table>

† Values used for the t-test to calculate the significance between the two samples.

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arms. While turning, 32 subjects maintained head control (fluctuated less than 15 degrees from the original position) and only 3 subjects were able to maintain the original head position.

It is interesting to note that no subjects in Ayres' original sample (N = 226) exhibited an absence of nystagmus. However, an absence of nystagmus was noted for one child with Down's syndrome in the present investigation (N = 35). Table 3 illustrates the distribution of total (left and right combined) nystagmus durations following rotation for children with Down's syndrome in the present investigation as well as learning-disabled and normal samples as reported by Ayres (27). The total mean duration for the population with Down's syndrome was less than that for the normal sample. The mean duration for male subjects with Down's syndrome was 15.1 seconds as compared to 15.0 for females. For both sex groups this yields a "low-average" range (+.7 and -.5 standard deviations, respectively) when compared to Ayres' standard deviation score equivalents on the normal sample.

**Discussion**

The analysis of data revealed that there was no significant difference in the duration of postrotary nystagmus between male and female subjects with Down's syndrome. However, the results did suggest a significant difference in duration of postrotary nystagmus between the children with Down's syndrome and the sample of normal children on whom the SCPNT was standardized. Subjects with Down's syndrome fell into the "low-average" range when compared to Ayres' normal sample. These results are not consistent with those of Kantner, et al. (12), who found a prolonged postrotary nystagmus in infants with Down's syndrome when compared to normal infants. The inconsistency between results of the two studies may be due to differences in population characteristics, age, and testing procedures. The subjects in this study were Caucasian middle-class children. Replication of the study with children from different races and socioeconomic background would be needed. Further study should also expand the age group of the population with Down's syndrome in order to provide further insight into the findings of Kantner, et al. and the results of the present investigation. It is also suggested that the procedure used by Kantner, et al. be replicated with the population in a future study to determine whether the difference in results was due to procedural (darkened vs. lighted room), or age (infant vs. school age) variance.

A study by Ayres (27) of 226 normal children suggested that nystagmus is atypical if it is found to be either excessively increased or reduced. The present investigation found that subjects with Down's syndrome had a greater percentage of reduced nystagmus below the normative range than Ayres' sample of normal children (20% compared to 10%). The reason for this difference requires further investigation. The Ayres' sample was drawn from California and the subjects in this study were in Utah schools. Subsequent research should include subjects that are age, sex, socioculturally, and geographically matched.

The compilation of clinical observations during testing provides additional information for interpretation of the nature of sensory integration in children. Ayres (27) reported that an average child did not lose balance following 40 seconds of rotation nor did the child exhibit loss of head balance. Subjects with Down's syndrome in this study exhibited balance loss more frequently (15% (43%) demonstrated some loss of balance during
rotation, and (91%) lost balance upon stopping abruptly. However, the majority of subjects were able to maintain head control during rotation with some fluctuation from the original head position. If the child's head had fluctuated up or down, this could have produced vertical or circular postrotary nystagmus (27, 31). Twenty-nine subjects (83%) expressed pleasure following rotation. Some continued to play with the nystagmus board after the test; others expressed a desire for more rotation. A few did not want to leave the rotating board.

Additional investigation of children with Down's syndrome must focus on other sensory systems (e.g., tactile, proprioceptive), thus enabling educators and clinicians to more effectively plan remedial strategies. Finally, there is a need to investigate the long-term impact of early sensorimotor intervention on the nystagmus responses and other parameters of function of children with Down's syndrome.

The results of this investigation must be interpreted with caution. Evidence of reduced nystagmus alone does not imply generalized vestibular dysfunction in children with Down's syndrome. In addition, the relationship between vestibular dysfunction and developmental delay has not been clearly established. Further research is needed in the above areas before definite conclusions can be drawn regarding the appropriateness of a sensory integrative approach with children with Down's syndrome. However, if further research establishes a relationship between low postrotary nystagmus and vestibular dysfunction, then vestibular stimulation, as advocated by some therapists (32-34), may prove to be a valuable treatment for this population.

Acknowledgment

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REFERENCES

2. Ayres AJ: Sensory Integration and Learning Disorders, Los Angeles: Western Psychological Services, 1972