Automatic Postural Responses of Deaf Children From Dynamic and Static Positions

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This paper describes automatic postural responses of deaf children during anterior body sway. Subjects were placed in a vestibular dysfunction (VDD) or vestibular nondysfunction (VNDD) group based on postrotary nystagmus response. They stood on an electrically driven platform, and brief support surface movement (12 cm/sec) elicited automatic postural responses under both static and dynamic conditions. Subjects underwent trials with and without vision, and electromyographical (EMG) data was recorded from posterior leg muscles. Both groups displayed some response characteristics found in previous reports (Nashner & Cordo, 1981), and under dynamic conditions the response latencies significantly decreased. However, the major finding was the response delay of some 40 msec by VDD subjects. It was proposed that this delay could in part be responsible for balance and movement problems exhibited by many deaf children.

If upright posture is unexpectedly disturbed, then stability is maintained by an automatic postural response. That is, the response is reflex in nature and not under voluntary control. Visual and vestibular feedback as well as support surface inputs, that is, feedback created by forces and motions of the feet and ankle joint (Nashner, Black, & Wall, 1982), interact to complete this long loop reflex response. In identifying neurophysiological characteristics of postural control, recent investigations have attempted to isolate these sources of sensory feedback and therefore highlight their individual importance (Forssberg & Nashner, 1982; Nashner & Cordo, 1981). Presumably, a logical extension of this approach is the study of subjects with known nervous system dysfunction such that posture is clinically disturbed (Badke & Duncan, 1983; Mauritz, Dietz, & Haller, 1980; Nashner et al., 1982). This latter approach also proposes practical as well as scientific outcomes to research. That is, known nervous system dysfunction can be equated with behavioral outcomes and thus assist the rehabilitation process. This study adopts such a philosophy by investigating the automatic postural adjustments of deaf children, specifically those with vestibular dysfunction.

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Equilibrium responses of deaf children are usually observed during a standardized assessment of motor ability. Variables such as dynamic or static equilibrium and eyes open or closed are manipulated. The inferior equilibrium skills of deaf children are well documented (Brunt & Broadhead, 1982; Myklebust, 1960) and appear to be inherent across various levels of motor ability (Brunt & Broadhead, 1983). Severe equilibrium problems are usually associated with those deaf individuals who have some degree of vestibular dysfunction (Paddon, 1959).

To investigate components of postural adjustment among deaf children, characteristics of leg muscle electromyographical (EMG) activity were analyzed with respect to induced anterior body sway under static and dynamic conditions, both with and without vision. Within the limits of our research protocol, work with normal populations (Forssberg & Nashner, 1982; Nashner & Cordo, 1981) has provided some guidelines to help determine expected results. For example, if upright posture is displaced anteriorly, then equilibrium is maintained with a distal-to-proximal (gastrocnemius to hamstrings) muscle activation pattern. The initial response latency is approximately 110 msec, with hamstring activity coming in some 12 msec later. This temporal-spatial structure remains relatively unchanged regardless of speed of displacement or during eyes open or eyes closed conditions. With young children, and possibly with vestibular dysfunction subjects (Nashner et al., 1982), these response latencies may well be increased and more variable.

**Method**

**Subjects**

Children participating in the study were selected from the elementary campus of the Texas School for the Deaf, Austin, Texas. All subjects had a severe/profound hearing loss. Subjects were grouped according to the results of a postrotary nystagmus test (Ayres, 1975), positive results from which indicated an active vestibular system mediating the vestibulo-ocular reflex. For this test, subjects sat cross-legged on a rotary board that completed a revolution every 2 seconds. After 10 rotations the board was stopped and the duration of nystagmus was noted. This procedure was repeated, rotating the child in the opposite direction. From the results of this test, subjects were grouped according to normal or slightly below normal nystagmus response (VNDD group, n = 3) or zero nystagmus response (VDD group), thus indicating vestibular dysfunction (n = 3). This data and further characteristics of the subjects are outlined in Table 1.

**Procedures and Apparatus**

An electrically driven platform provided brief, posterior support surface perturbations at four speeds ranging from 12 cm/sec to 18.25 cm/sec. These movements were sufficient to evoke an automatic postural response to anterior body sway without destabilizing the subjects. Subjects stood on the platform, with feet shoulder-width apart and arms folded. They underwent eight trials with eyes open and then eight trials with eyes closed. Each trial began with a platform movement of 12 cm/sec (static condition). This was followed

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1Appreciation must go to the faculty and children of the Texas School for the Deaf for their assistance in the study.
Table 1
Subject Characteristics and Postrotary Nystagmus Results

<table>
<thead>
<tr>
<th>Group</th>
<th>Subject</th>
<th>Sex</th>
<th>Age (mths)</th>
<th>Etiology of deafness</th>
<th>Nystagmus scores</th>
</tr>
</thead>
<tbody>
<tr>
<td>VNDD</td>
<td>1</td>
<td>F</td>
<td>96</td>
<td>Hereditary</td>
<td>12, SD = 1.0</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>F</td>
<td>114</td>
<td>Goldenhars</td>
<td>10, SD = 1.3</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>F</td>
<td>123</td>
<td>Rubella</td>
<td>19, SD = 0.2</td>
</tr>
<tr>
<td>VDD</td>
<td>4</td>
<td>F</td>
<td>127</td>
<td>Meningitis</td>
<td>0, SD = 3.0</td>
</tr>
<tr>
<td></td>
<td>5</td>
<td>M</td>
<td>129</td>
<td>Hereditary</td>
<td>0, SD = 3.0</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>F</td>
<td>99</td>
<td>Meningitis</td>
<td>0, SD = 3.0</td>
</tr>
</tbody>
</table>

by four continuous platform perturbations of different speeds, presentation of which were counterbalanced across trials, and included a platform movement also at 12 cm/sec (dynamic condition). The duration of each trial was approximately 8 seconds and complete stability was only momentarily maintained prior to a subsequent perturbation. Temporal and spatial automatic EMG responses were monitored from gastrocnemius and hamstring muscles. Surface EMG electrodes were placed centrally on the muscles and EMG signals were transmitted to four amplifiers (Tektronix AM 502 Differential Amplifiers by Harvard Apparatus Preamplifiers). Muscle activity was recorded with a Hewlett-Packard 396A instrumentation tape recorder in conjunction with a Harvard Apparatus 10-speed chart mover that provided hard copy from which the data was analyzed.

Statistics

For both distal and proximal muscles the data was analyzed by a 2 by 2 by 2 (group by platform movement by vision) analysis of variance with repeated measures on the last two factors. The dependent measures were mean response latencies (msec) for eight trials at the platform speed of 12 cm/sec from static and dynamic positions (platform moved a distance of approximately 1.5 cm). The .05 level of significance was accepted on all analyses.

Results and Discussion

Response latencies for both the gastrocnemius and hamstring muscles are shown in Figure 1. For the gastrocnemius, analysis yielded a main effect for group only ($F = 11.69, 1/4 \text{ df}$). With eyes open the VNDD group yielded a mean latency of 141 msec (SD = 12) and 134 msec (SD = 12) during platform movement. Minimal changes existed for the eyes closed condition. However, the VDD group recorded delayed response latencies with respective means being 178 msec (SD = 7) and 168 msec (SD = 4). Again minimal differences were noted for different visual conditions.

For the hamstrings, main effects for group ($F = 9156, 1/4 \text{ df}$) and platform condition ($F = 10.59 1/4 \text{ df}$) were recorded. For the VNDD group, eyes closed condition, mean response latencies decreased from 179 msec (SD = 25) to 157 msec (SD = 17).
Again the VDD group displayed increased response latencies which also decreased during platform movement. Mean responses for the static condition were 227 msec (SD = 15) and 213 msec (SD = 14) and during platform movement 204 msec (SD = 12) and 203 msec (SD = 3). There were no significant interaction effects for either analysis.

The performance of both groups coincide with what appears to be invariant characteristics of an automatic postural response (Nashner & Cordo, 1981). That is, in general only minimal differences existed between eyes open and eyes closed conditions, and clearly both groups displayed a distal to proximal muscle activation pattern. The reduction in response latencies with eyes closed may well reflect an overall increase in muscle tension. Both groups also displayed decreased latencies to the dynamic platform condition. This was certainly more evident for the proximal musculature and was presumably in response to more stringent control over upper body displacement during the dynamic condition. Interestingly for the VNDD group, this effect occurred only during the eyes closed condition and otherwise the addition of visual monitoring (together with an intact vestibular system) during displacement was sufficient to maintain the performance noted during the presumably less demanding static condition.

Obviously, the major difference between the normal and vestibular dysfunction group was the response latencies. In fact, the gastrocnemius response for the normal group was a little delayed when compared to previous findings (Forssberg & Nashner, 1982). However, the fact that subjects 1 and 2 also showed a below-average nystagmus response may well explain this. Figure 2 displays the temporal and spatial EMG structure of a typical response. Understandably, if equilibrium displacement was unexpected or faster, then any response delay must contribute to balance loss. Also, during tasks on a narrow balance beam the somatosensory input involving the foot and ankle joint is reduced, thus further delaying the automatic postural response (Nashner, 1982). Of further concern is how this response delay interacts with skilled movement or subsequent responses within a movement sequence. To maintain body sway within the parameters of expected normal disturbance, then, this delayed response must be accompanied by a more aggressive muscle contraction. The closer a child approaches postural limits then, the more this contraction will become aggressive, and certainly inappropriate, if subsequent responses are forthcoming. Needless to say, with experience some children may well develop postural strategies to overcome these difficulties.
This study provided an initial investigation into automatic postural adjustments of deaf children during anterior body sway. It was proposed that a delayed postural response exhibited by those deaf subjects with vestibular dysfunction could contribute to equilibrium and skilled movement disorders. With the exception of this delayed response, other properties of the automatic postural response appeared to be intact. However, under less stable conditions (dynamic condition) different response strategies between the groups in controlling trunk displacement were noted. Studies linking upper limb coordination with postural displacement will provide further insight into the cause of movement problems noted in many deaf children.

References


