The Use of a Weighted Vest To Increase On-Task Behavior in Children With Attention Difficulties

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Key Words: attention deficit disorder with hyperactivity • pressure • school based occupational therapy

Objective. *Children described as having attention deficit hyperactivity disorder often demonstrate inability to sustain visual attention during classroom fine motor activities. This study investigated the effect of wearing a weighted vest (deep-pressure sensory input) on children's on-task behavior in the classroom.*

Method. *Four students with documented attention difficulties and hyperactivity were timed with a stopwatch to measure their on-task behavior during fine motor activities in the classroom. All 4 students were timed for six 15-min observations without wearing a weighted vest and for six 15-min observations while wearing a weighted vest.*

Results. *On-task behavior increased by 18% to 25% in all 4 students while wearing the weighted vest. Additionally, 3 of the 4 students frequently asked to wear the vest other than during the observation times.*

Conclusion. *These preliminary findings support the hypothesis that wearing a weighted vest to apply deep pressure increases on-task behavior during fine motor activities.*

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Children described as having attention deficit hyperactivity disorder (ADHD) show "a persistent pattern of inattention and/or hyperactivity-impulsivity that is more frequent and severe than is typically observed in individuals at a comparable level of development" (American Psychiatric Association, 1994, p. 78). These children often exhibit sensory processing problems such as being easily distracted by irrelevant stimuli that is ignored by others, frequently shifting from one uncompleted activity to another, having difficulty remaining seated when expected to do so, performing messy written work, making noises or talking excessively, and grabbing objects or touching things excessively.

Children with ADHD who exhibit sensory processing problems usually cannot function effectively within the regular classroom setting without accommodation and special education interventions (Ayres, 1979). Such children may be in constant motion or fatigue easily and have an activity level that is unusually high or unusually low. Behaviorally, these children are often impulsive, easily distractible, and exhibit a lack of planning ability. They often cannot participate in seated activities, particularly fine motor activities, long enough to complete tasks. Theoretically, these children have sensory systems that are immature and work improperly, so abnormal neural signals are being sent to the brain cortex that interfere with "normal," organizing brain activity (Kranowitz, 1998). The brain, in turn, becomes overstimulated, making it difficult

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for the child to organize his or her behavior and to concentrate (Hatch-Rasmussen, 1995). This neural sequence often results in negative emotional responses or outbursts, so the child with ADHD is seen as a behavior problem (Hallowell & Ratey, 1994; Kranowitz, 1998).

Traditionally, the treatment of choice for children with ADHD has often been medication. Medications used to treat ADHD symptoms are believed to act on the ascending reticular activating system to help dampen some of the activating stimuli that cause hyperactivity; medications accomplish this by increasing the neurotransmitters (dopamine, norepinephrine) that are suspected of being deficient (Silver, 1993; Taylor, 1994). Serotonin levels also have been found to be abnormally low in children with hyperactivity and attention deficits (Gainetdinov et al., 1999). Medication most likely affects the symptomology of ADHD by restoring balance among the brain chemicals.

Children with attention problems are often referred to occupational therapists for concerns regarding poor fine motor skills as well as other adaptive problems such as concentration difficulties, increased levels of purposeless activity, and inability to interact successfully within the classroom environment (Royeen & Lane, 1991). *Sensory modulation disorder* is a descriptive term that occupational therapists use to describe a person who "over responds, under responds, or fluctuates in response to sensory input in a manner disproportional to that input" (Koomar & Bundy, 1991, p. 268). A therapeutic activity program geared toward helping children learn to modulate their arousal levels effectively, referred to as sensory integration treatment, is often used in occupational therapy treatment for children with problems resulting from ADHD (Fisher, Murray, & Bundy, 1991).

School-based therapists increasingly are using weighted vests as an intervention strategy for children with conditions that affect sensory modulation and attention span, such as autism and ADHD (Joe, 1998; Maslow & Olson, 1999). Weighted vests are used as a means of applying deep pressure, which is believed to decrease purposeless hyperactivity and increase functional attention to purposeful activity (Miller, Moncayo, Treadwell, & Olson, 1999).

Farber (1982) supported a beneficial response to the application of deep pressure, suggesting that maintained pressure is calming as it facilitates an increase in parasympathetic or relaxed tone. In describing her own autism, Temple Grandin related her experience of severe anxiety and how deep pressure ultimately helped her reduce the anxiety's debilitating effects by reducing overall arousal and facilitating attention and awareness (Grandin & Scariano, 1986). In studies done with children with autism, deep pressure has been found to have a calming effect (Edelson, Edelson, Kerr, & Grandin, 1999; Krauss, 1987; McClure & Holtz-Yotz, 1991; Miller et al., 1999; Zissermann, 1992). No published studies on the effects of deep pressure with children with ADHD were found.

Proprioception and deep touch-pressure are types of sensory information that can produce a calming effect (Ayres, 1972; Farber, 1982; Knickerbocker, 1980). Both are carried by the dorsal column system to higher levels in the thalamus and the reticular formation and then up to sensory areas in the parietal lobe of the cerebral cortex. According to Royeen and Lane (1991), "Since the reticular formation mediates arousal, the reticular projections of the dorsal column pathway may be related to the efficacy of these inputs in decreasing arousal and producing calming" (p. 115). The dorsal column system also has some connections with the limbic system via the hypothalamus and the anterolateral system. This functional redundancy in the nervous system may play a role in the efficacy of sensory integration intervention (Fisher et al., 1991).

An example of the nervous system's functional redundancy is seen in the registration of deep pressure. Deep pressure is registered in the limbic system, hippocampus, and reticular activating system and may stimulate production of neurotransmitters to modulate arousal levels, similar to the effects of medications. The action of the neurotransmitters norepinephrine, epinephrine, and serotonin is associated with the limbic structures and components of the reticular system, hypothalamus, and cortex (Ashton, 1987). Medications allow more of these neurotransmitters to be available to the brain, influencing the level of arousal in the nervous system of a child and thereby controlling hyperactivity and helping to increase the child's ability to attend (Cohen, 1998; Hallowell & Ratey, 1994). The reticular system is aroused to varying degrees of alertness by sensory stimuli (Ayres, 1972), and touch-pressure appears to be particularly effective in dampening overly activating stimuli.

Deep pressure also sends sensory information into the Purkinje cells in the cerebellum, which then work to dampen stimulation entering the reticular formation through brain chemistry or neurotransmitters (Hanschu, 1998; Reeves, 1998). Purkinje cells are rich in serotonin and are responsible for inhibition of motor activity (Edelson, 1995). Children with ADHD have been found to have high levels of hyperactivity related to lower levels of serotonin in their blood (Gainetdinov et al., 1999; Taylor, 1994). Deep pressure may stimulate the increase in serotonin, as well as other neurotransmitters, to create a natural calming on the central nervous system in the child with ADHD.

Weighted vests can provide deep, sustained pressure. Current school-based occupational therapy practice in the United States often incorporates the use of weighted vests to increase children's attention to school-based tasks (Joe, 1998; Maslow & Olson, 1999). The vests can be constructed inexpensively from materials that are attractive and do not stand out as a "therapeutic garment" so that the child does not look different from his or her peers. Vests can be administered by teachers (under the guidance of an occupa-

tional therapist) without removing the child from the classroom setting. They can be worn during purposeful activity within the child's learning environment, and children can even don the vests themselves. According to Hanschu (1998), "The right sensation, in the right amount, at the right time, can profoundly influence arousal, alertness, attention, and how ably a person makes adaptive responses all day long" (p. 1). As Farber (1982) pointed out, however, when using maintained pressure on any part of the body, deciding how long and how often to apply the pressure is difficult. A more rigorous analysis is needed to measure the clinical effects of using a weighted vest to apply deep pressure for the purpose of increasing on-task behavior. Such analysis would help in determining the overall effectiveness of using such a vest to increase attention to purposeful activity and contribute to evidence-based practice (Abreu, Peloquin, & Ottenbacher, 1998). The purpose of this study was to measure on-task behavior in children with attention difficulties while wearing a weighted vest calibrated at 5% of each child's body weight for a 15-min period while engaged in classroom fine motor activities.

Method

Sample

A convenience sample of 4 children receiving school-based occupational therapy services was selected for the study. The children had been diagnosed as having ADHD by a physician or scored in the high/problems range on the hyperactivity and attention scales of the Conners' Teacher Rating Scales (CTRS-39; Conners, 1989). The CTRS-39 requires that the teacher rate a student on 39 behavioral items from observations in multiple settings (playground, classroom, lunch) from which standard methods are used to derive *T* scores for the student. A *T* score of 65 or more indicates a high/problem area. The scales were scored by the school social worker and made available for the parents to share with their physician to help in making a determination of ADHD.

The 4 children selected for the study attended school in a Midwestern rural school district. Their ages ranged from 5 years, 9 months to 6 years, 10 months. During the previous academic year, all these students had attended special education or at-risk preschool programs in which developing school-readiness skills had been the primary goal. Students 1 and 2 were girls and eligible for special education services as speech and language impaired. Students 3 and 4 were boys and eligible for special education services as physically or otherwise health impaired due to ADHD as diagnosed by a physician. Before as well as during the study, Student 3 received medication as prescribed by his physician.

All 4 students received school occupational therapy services. The occupational therapist described each child as having a sensory modulation problem exhibited by excessive movement (constant playing with hair or clothing, picking at body parts such as nails, reaching or playing with objects excessively, unnecessarily getting in and out of the seat, rolling on the floor), overreaction to extraneous stimuli, and inability to complete an activity successfully. According to the occupational therapy clinical evaluation and as observed within the classroom, all 4 students had considerable difficulty writing their first names within the spaces of 1-in. ruled paper and had difficulty writing letters so that they rested on a line. When coloring, all 4 students did not stay within boundaries of simple shapes, and cutting did not remain on the lines of simple shapes.

The children were timed for on-task behavior while engaged in classroom fine motor activities, and data were recorded in the baseline phase and intervention phase. Varied activities such as coloring pictures, cutting shapes and gluing them onto paper, writing letters of the alphabet within squares on paper, counting out small objects according to a designated number, and stringing beads were typical table-top activities performed during the timed observations.

Instruments

Weighted vests. Denim vests that buttoned down the front were purchased inexpensively from a thrift shop. Pockets from old jeans were removed and sewn into the inside of the vests so that weights could be placed into the pockets and would be evenly distributed. The pockets were positioned high enough on the chest anteriorly to prevent the weights from resting on the child's hips or legs when seated. A pocket was positioned posteriorly between the scapulae just below the scapular borders to ensure that the weight was supported from the shoulder girdle. The placement of the weights higher up on the shoulder girdle rather than predominately below chest level has been used successfully by other therapists (Hanschu, 1999). Weights were purchased in 1/2-lb, 3/4-lb, and 1-lb fabric pouches and placed into the interior pockets so that they were evenly distributed front and back, with a total weight as close to 5% of the child's body weight as possible.

Stopwatches. Two dependable stopwatches and a timer set at 15 min were used.

Recording sheets. The total time a child spent on task during an activity was recorded to the hundredth of a second. The student number, date, and activity the class was instructed to perform for each observation were recorded.

Consent forms. Written permission to carry out the study was obtained from the special education supervisor of the school district. Parents signed consent forms authorizing their children to participate in the study after the purpose of the research was explained to them.

Procedure

The study was a quasi-experimental, single-system, AB

design (Bloom, Fischer, & Orme, 1995; Ottenbacher & York, 1984). All prescribed medications and special education services that the students were eligible to receive, such as occupational therapy and speech–language services, continued as normally scheduled during the baseline and intervention phases. The study was initiated after the beginning of the second school semester so that the children would be familiar with classroom activities, procedures, and expectations.

Two observers were used in the study. One observer was the author who was also the occupational therapist for the students at the study site. The other observer was an occupational therapy fieldwork student. Before beginning the study, the two observers randomly selected 11 nonparticipant students and practiced timing them performing the same types of classroom fine motor tasks as those timed in the baseline and intervention phases of the study. On-task behavior was defined as engagement in those processes that were necessary to complete the activity assigned by the teacher and were a part of the expected process. A child was timed as being on task while visually focused on the activity and engaging in the processes to complete the activity, such as reaching for required materials (scissors, crayons, etc.) as needed. Handling or reaching for materials no longer needed was timed as off task. Dropping something on the floor was allowed once but was timed as off task if more frequent. Talking to other children, unless continuing to work, was timed as off task. Interater agreement was defined as the observers being within 10 sec of one another in their timed observation of a child's on-task behavior. Practice timings with the 11 nonparticipant children were completed, with the last 6 consecutive timings being within 10 sec of one another.

The occupational therapist-observer showed the vests to each child on a day before observations began. The therapist fit the vest to each child, weighing the child so that the weights could be calibrated to 5% of his or her weight as closely as possible, and ensured no distress to the shoulder girdle or posture. The children were asked whether the vest felt comfortable and whether they would wear it in the classroom when the teacher asked them to wear it along with some other children. They were not told the purpose of the vest nor that they would be timed while wearing it. Another volunteering child was given an unweighted vest to wear at the same time in the classroom so that the children in the study would not feel singled out. The children were also given the vest to wear at times other than during the observation periods so that they would not learn that putting on the vest meant that they would be observed or to "try" and be especially on task.

The observers spent time within the two study classrooms before beginning the baseline phase so that the children would not be distracted by their presence. The baseline phase spanned six different days within a 15-day period during which on-task behavior (dependent variable) was measured in seconds during a 15-min activity, totaling six observations for each child. The children were observed at different assigned times in accordance with their schedule of attendance (morning or afternoon kindergarten, preprimary). Each child's scheduled observation time was maintained throughout the study during the six baseline and six intervention observations.

Timings began after the teacher had given instructions to the class. Observations were recorded during a table-top activity while the child was engaged in organizing materials, drawing, coloring, writing, pasting, or cutting as the teacher had instructed. One observer timed each child's on-task behavior during the baseline phase, and the other observer timed each child's on-task behavior during the intervention phase without knowledge of the baseline outcomes. The total time on task during each 15-min period was recorded as well as the name of the activity assigned that particular day.

The intervention phase followed in which observations were also completed within 15 days. During the intervention phase, the 4 students wore a weighted vest and was timed by the other observer for six 15-min periods as described in the baseline phase. Each child's vest was put on 5 min before the beginning of the timing and removed after the completion of the 20-min to 30-min activity in which they were involved. Informal interviews with the classroom teachers and aides also were conducted to provide additional qualitative information regarding the outcomes of using the vest.

Results

Behavioral Data

Two methods of data analysis were used in this study to combine the strengths of several methods while avoiding some of their limitations (Bloom et al., 1995). The 2–standard deviation band approach (Bloom et al., 1995; Gottman & Leiblum, 1974; Ottenbacher & York, 1984) was chosen as a good fit because it is most useful with a relatively small number of baseline observations and the same number of intervention observations with some fluctuation in the baseline data but with no stable pattern present (Bloom et al., 1995). Because the study involved fewer than seven baseline observations, however, it was safer to assume that the data were autocorrelated (Bloom et al., 1995), as there could be some growth expected in attention over time due to practice or maturity (in spite of design precautions). Furthermore, transformation of data to remove autocorrelation, if present, could result in loss of data. Thus, to take into account the possibility that the data might be autocorrelated and not independent as assumed in the 2-standard deviation method, the celeration line approach was used to determine statistical significance because it is a better fit when autocorrelation of data is pre-

sent (Bloom et al., 1995). The celeration line also takes any trends in the baseline into account.

Figure 1 represents the results of the data collected during the baseline phase and the intervention phase when the students were wearing the weighted vests while performing fine motor activities within the classroom. A mean number of minutes that each child was on task were computed for the baseline. The values associated with 2 standard deviations above the baseline mean were determined, with a horizontal line drawn on the scatterplot of each child's data representing this value. The lines are extended into the intervention phase to determine whether at least two consecutive observations (data points) during the intervention phase fell above the 2-standard deviation line (+2SD) (Gottman & Leiblum, 1974). Using the 2-standard deviation band method of analysis, all students except Student 2 demonstrate 2 consecutive data points above +2SD, indicating that a significant change ($p < .05$) occurred from the baseline phase to the intervention phase for Students 1, 3, and 4.

Additionally, a celeration line was also computed using median scores in the baseline (Gingerich & Feyerherm, 1979) and extended into the intervention phase; the extension predicts what course the students' on-task behavior would take in the absence of any intervention. Statistically, a significant change has occurred in the intervention phase if the required proportion of data points above the celeration line in that phase is sufficiently different from the number above the celeration line in the baseline phase. To represent a significant increase at the .05 level (Bloom et al., 1995), Students 1 and 2 needed 6 data points to be above the celeration line; Student 3 needed 5; and Student 4 needed 4. As seen in Figure 1 for all 4 students, the criteria of the necessary number of data points falling above the celeration line to indicate a significant change in the intervention phase at the .05 level was met.

Ottenbacher and York (1984) cautioned that statistical analysis of data from single-system designs should be interpreted as an adjunct to visual analysis because the presence of serial dependency or unusual trends may compromise results. Although serial dependency and the presence of trends have been taken into consideration by using both the celeration line and 2-standard deviation band methods of analysis, visual analysis further supports the results that a significant change in on-task behavior occurred during the intervention phase. All 4 students showed a regressing trend line in Figure 1, but Students 2 and 3 appear to be getting significantly worse over time as illustrated by the steeper downward slope of the trend line. Only during the intervention phase with the use of the vest did any on-task behaviors measure more than 2 standard deviations above the mean, showing an upward trend.

The change from the baseline phase to the intervention phase with Student 1 indicates a 25% mean increase in the amount of time that this student was on task while wearing the vest (see Figure 2). The change from the baseline phase to the intervention phase with Students 2, 3, and 4 indicates a mean increase of 17% to 18% in on-task behavior while wearing the vests. Student 1's (female, no medication) mean time spent on task during the baseline phase was only 54% and increased to a mean of 79% while wearing the weighted vest. Student 2 (female, no medication) demonstrated a mean on-task behavior of 63% during the baseline with an increase to 81% while wearing the vest. Student 3 (male, and receiving medication at the same scheduled time during both phases) demonstrated a mean of 64% for on-task behavior during the baseline phase, increasing to 82% while wearing the vest. Student 4 (male, no medication) showed a baseline mean of 64% with an increase to a mean of 81% for on-task behavior while wearing the vest.

Qualitative Information

Perhaps the most revealing questions to raise are those that are hard to answer with quantitative research methods. However, these questions give us a view of the child's reality and the meaning the intervention has for the child. Yerxa (1987) suggested that "the research subject might be one of the most important sources of information" (p. 417). The teachers reported that 3 of the 4 students (1, 3, 4) asked to wear the vest at times other than during the timed observations and wanted to put the vest on themselves. Student 3 asked to wear the vest during an occupational therapy treatment session (after completion of the study). The vest that was fitted to him for the study was not available in the occupational therapy room, so the therapist gave him another vest with less weight in it. He responded that this vest "did not have the same amount of weight in it," appearing to be aware of the difference in a 1/2 lb of pressure on his body. When asked why he wanted to wear the vest, Student 3 responded, "I like to wear the vest. It's comfortable." Student 4 wanted to keep the vest on after one observation was completed, and he had been wearing it for 20 min. He told the observer that the vest "made him feel good." Student 1 asked to wear the vest every day when she came into the kindergarten class, and the teacher believed that the student would have liked to have worn it all day. This child was observed to be the most hyperactive of the study group and demonstrated the greatest increase in on-task behavior while wearing the vest.

Yerxa (1987) also suggested that we "need to ask questions about how children relate to their peers, the nature of their play, and how satisfied they are with what they do" (p. 416). The classroom staff members for Students 1, 2, and 3 commented to the occupational therapist-observer that they noticed a visible difference in all 3 students, especially in Student 1. One support staff member commented that "the

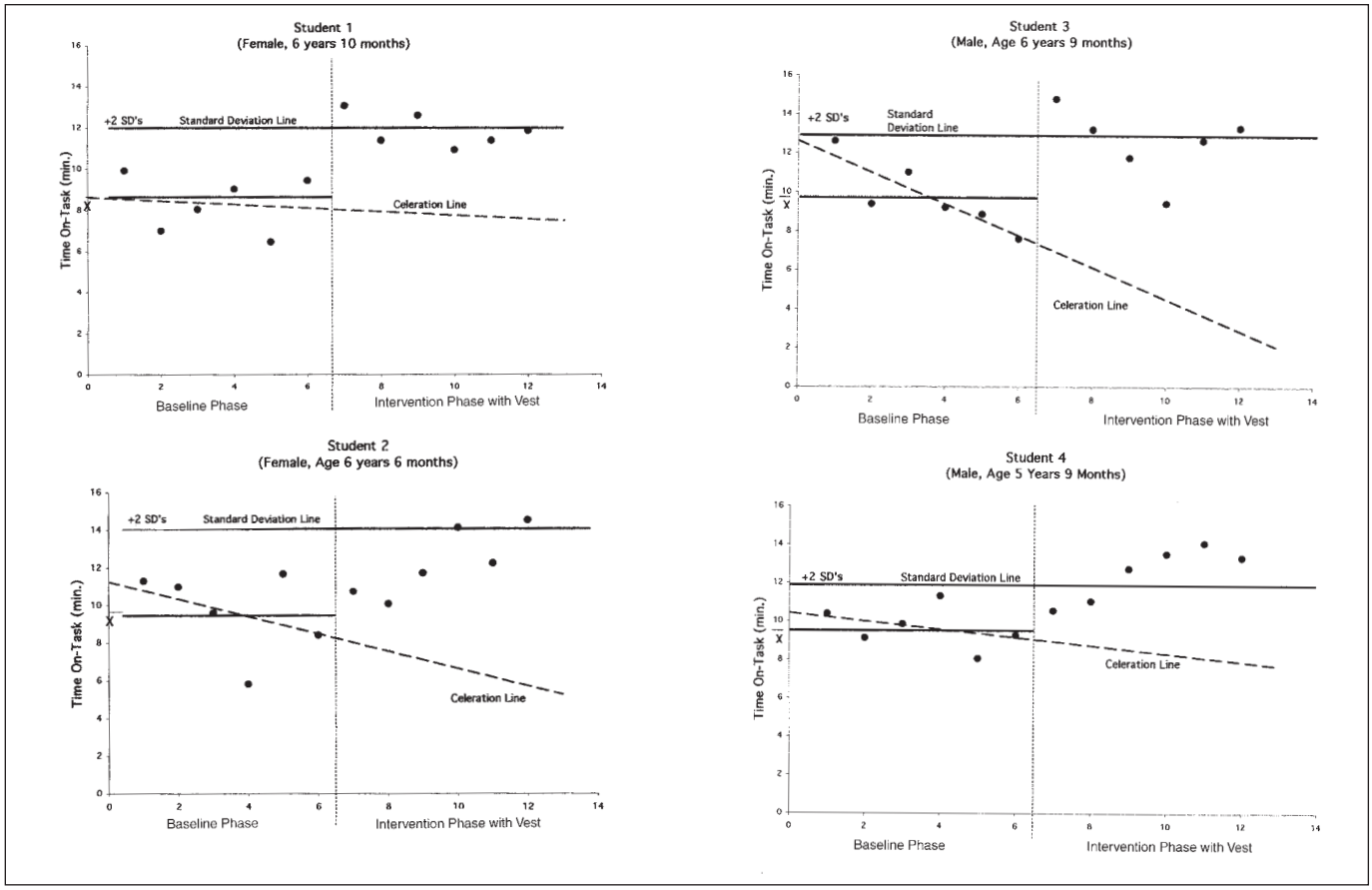

Figure 1. The 2-standard deviation band method is used to evaluate changes in minutes spent on task during a fine motor activity from the baseline phase to the intervention phase during which a weighted vest was worn. Two consecutive data points above the +2SD band during the intervention phase indicates a change at the .05 level. The celeration line method requires (for $p < .05$ level change) 6 data points above the celeration line during the intervention phase for Students 1 and 2, 5 data points for Student 3, and 4 data points for Student 4.

vests really help the kids during centers [seated, fine motor activities]" and that "the vest especially kept [Student 1] in her seat." A staff member from the after-kindergarten school program asked to use the vest with Student 3, commenting that it seemed to help him organize himself on the playground and not run around so purposelessly; he seemed to be "slowing down more and stopping to think" when wearing the vest and to be interacting with other children more appropriately. She observed that without the vest, Student 3 "was just all over the room."

Discussion

Yerxa (1991) stressed that in occupational therapy, a need exists "to emphasize the skills and capabilities of the whole person and include the experience of engagement in occupation" (p. 201). This study attempted to measure the level of engagement in occupation of 4 students 5 to 6 years of age with attention difficulties by measuring on-task behavior while performing fine motor activities within their natural environment—the classroom. Weighted vests were used to apply deep-pressure sensory input and measure whether it changed on-task behavior.

Although a small sample size was used, the behavioral results indicate a clinically significant increase in on-task behavior in all 4 students while wearing a vest containing weights totaling 5% of their individual body weight. All 4 students demonstrated significant changes at the .05 level in on-task behavior while wearing the weighted vests according to the celeration line method of analysis. Students 1, 3, and 4 showed a significant change at the .05 level according the 2-standard deviation band method of analysis.

These findings strongly suggest the need for further inquiry. Videotaping, as suggested by Miller et al. (1999), was not used so as not to distract the children or make them feel self-conscious. It is very important to watch the entire observation period than in intervals. Observing the entire activity allows the observer to determine quickly whether the child's actions are on task as part of the activity or are purposeless, off-task behaviors that might be misinterpreted as on task if the sequence of the activity is not carefully observed in its entirety.

The AB design was used instead of the ABA design because of ethical concerns with discontinuing the vests, which appeared to be an effective intervention. Hence, the design limits this study's generalizability. Use of an ABA or alternating treatment design would further add to the power of a follow-up study and strengthen the validity of results by decreasing the effects of variables such as matu-

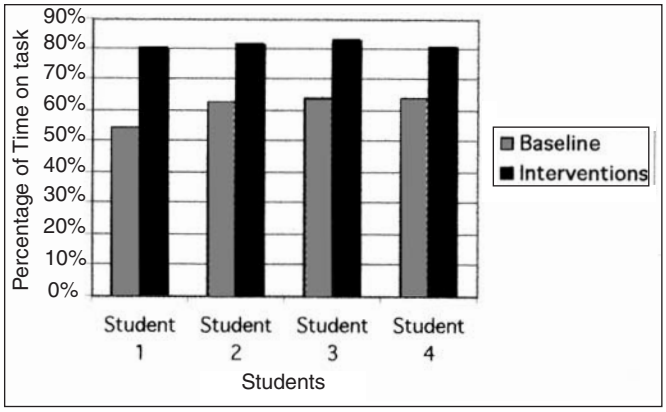

Figure 2. The mean percentage of time on task during the baseline phase (without the weighted vest) and the intervention phase (with the weighted vest).

ration or practice. Another limitation of this study is the small sample size. Future research using a larger sample size would increase generalizability, and an increase in age range would increase the generalizability of the findings to other age groups. Future studies can help to determine how different amounts of weight affect on-task behavior by using the 2-standard deviation method.

Conclusion

The use of a weighted vest as a means of applying deep-pressure sensory input is practical and convenient for classroom use. It is low cost and easily transported to therapy sessions with occupational therapists and speech–language therapists and for use in other learning environments where optimal on-task behavior is required for maximal learning.

This study supports the efficacy of using weighted vests on children with attention difficulties to increase on-task behavior. A significant increase ($p < .05$) in on-task behavior was demonstrated in 4 students when the weighted vests, calibrated at 5% of their individual body weight, were used during the intervention phase. ▲

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