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Behavioural and Physiological Effects of Weighted Vests for Children with Autism

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By

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ABSTRACT

Tactile and proprioceptive input provided by weighted vests is thought to decrease sensory modulation dysfunction in children with autism. This study investigated behavioural and physiological effects of weighted vests for ten children with autism, ages 3 to 10, in a classroom setting. A single-case, ABCBC design was used where A =behavioural baseline without vest or heart rate monitor; B = unweighted vest and heart rate monitor; C = vest with 5% body weight and heart rate monitor. Observers, blinded to treatment condition, rated targeted behaviours for each participant through video taken during structured table-top activities typical of the classroom routine. Teachers, also blinded to treatment condition, rated each child's behaviour with the Conners' Global Index following each phase of the study. Educational aides, not blinded to treatment condition, provided subjective feedback about the effects of the weighted vest for each participant. Heart rate was collected when participants wore the vest.

Results were mixed regarding the effects of weighted vests for children with autism. Objective data provided evidence to support the use of weighted vests to decrease off-task behaviours with some, but not all, children with autism and sensory modulation dysfunction. Weighted vests did not decrease motoric stereotyped behaviours in any participant, but did decrease verbal stereotyped behaviours in one participant. Heart rate did not decrease with the weighted vest. Subjectively, all aides reported that weighted vests were effective in improving behaviours in all participants at least some of the time. All teachers and aides reported that weighted vests were

appropriate modalities to use in the classroom and wanted to continue using weighted vests following the study.

Although weighted vests may be an appropriate modality to include as a component of intervention with some children with autism, results were not strong or consistent across participants. The results do not support the use of weighted vests in isolation to improve classroom function in children with autism.

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Introduction

Awareness of autism has increased significantly in recent years due to frequent media exposure and increased research related to its identification, potential causes, and interventions and treatments (Johnson & Myers, 2007). Although not a diagnostic criterion for autism, considerable evidence exists that the majority of individuals with autism experience differences in sensory processing, such as over-reactions to typically non-noxious auditory or touch stimuli (Huebner & Dunn, 2001). Differences in sensory processing can contribute to significant difficulties in self-care activities, leisure pursuits, social interaction and academic endeavors (Bar-Shalita, Vatine, Parush, 2008).

Interventions that claim to address sensory processing are used frequently and are well received by parents of children with autism (Baranek, 2002; Goin-Kochel, Mackintosh & Myers, 2009). Most of these interventions are based on the theory that providing carefully graded sensory inputs, especially tactile and proprioceptive inputs, enhances neurological function and decreases problems caused by difficulties modulating sensory input (Huebner & Dunn, 2001). In two independent surveys examining occupational therapy practice in pediatrics, interventions targeted at sensory processing were the most common recommendation for children with autism across home, school and community settings (Case-Smith & Miller, 1999; Watling, Deitz, Kanny & McLaughlin, 1999). One frequently used specific intervention modality is the weighted vest (Olson & Moulton, 2004a, 2004b). However, there is very little conclusive evidence supporting the efficacy of interventions designed to address sensory dysfunction, including weighted vests. Several authors (e.g., Baranek, 2002; Dawson & Watling, 2000; Johnson & Myers, 2007; Watling et al., 1999) have stressed the need for empirical research in this area. The aim of this study was to systematically investigate effects of weighted vests for children with autism.

Autism

Definition and Core Features of Autism

Leo Kanner published the seminal paper on "autistic disturbances of affective contact" in 1943. Similar to the present diagnostic criteria for autism, Kanner discussed an inability to relate to others in a typical way, deficits in verbal and non-verbal communication, restricted activity preferences, an obsessive need for sameness, and the presence of stereotyped movements. He also discussed behaviours indicative of odd responses to sensory stimuli, such as a fear of certain noises or a lack of overt response to pain or heat.

Autism is now viewed as part of a continuum of disorders, collectively known as pervasive developmental disorders in the Diagnostic and Statistical Manual of Mental Disorders, 4th edition, text revision (DSM-IV-TR) authored by the American Psychological Association (APA, 2000). The terms 'autism' and 'autism spectrum disorders (ASD)' are often used interchangeably in clinical practice and research to refer to three of the pervasive developmental disorders defined in the DSM-IV-TR: autistic disorder, Asperger syndrome and pervasive developmental disorder – not otherwise specified (PDD-NOS; Johnson et al., 2007). In this dissertation, the term 'autism' refers to autistic disorder as defined in the DSM-IV-TR (APA, 2000), and the term ASD refers to autistic disorder, Asperger's syndrome and PDD-NOS. Current diagnostic criteria for autism include qualitative impairments in social interaction and communication and restricted or stereotyped behaviours, activities and interests that are present before age three (APA, 2000). Examples of social and communicative impairments include poorly modulated eye contact, odd facial expressions, a lack of social or emotional reciprocity, a lack of shared enjoyment with others, and delayed, absent or idiosyncratic language. Examples of restricted or stereotyped behaviours, activities and interests include a rigid adherence to non-functional routines or rituals, repetitive motor mannerisms, and a preoccupation with parts of objects.

Prevalence of Autism

The diagnosis of autism can be made reliably as early as two years of age (Zwaigenbaum et al., 2009). Current prevalence estimates of 6 per 1000 (1 in 150 individuals) makes ASD among the most prevalent pediatric developmental disorders (Rice et al., 2007). Prevalence rates for autistic disorder specifically are estimated at 2.2 per 1000 (1 in 455 individuals; Fombonne, Zakarian, Bennett, Meng, & McLean-Heywood, 2006). The ratio of males to females for autistic disorder is approximately 4:1 (Fombonne, 2003).

Etiology of Autism

Autism is a complex neuro-developmental disorder with unknown etiology (Johnson & Myers, 2007). There is significant heterogeneity in clinical phenotype, and no symptoms or biomarkers are unique or universal to autism (Lord & Spence, 2006). There has been significant scientific interest in identifying homogeneous subtypes of autism based on phenotype and genetic or neurobiological makers, but this has yet to be achieved (Lord & Spence; Rapin & Tuchman, 2008; Rutter, 2005). There is general consensus that the causes of autism and ASD are multi-factorial, with the most common theories based on a combination of genetic and environmental influences (Hyman, 2006).

Genetic influences in autism. Family studies indicate a 60% concordance rate for monozygotic twins for autism and a 90% concordance rate for the broader autism phenotype. Alternatively, the concordance rate for autism in dizygotic twins is approximately 5% (Rutter, 2005). These findings suggest strong genetic underpinnings for autism. It is estimated that there are between 3 and 12 susceptibility genes for autism. Some scientists propose that the broad phenotype of autism may be partially explained by the influence of different genes on different behaviours (Happe, Ronald & Plomin, 2006), whereas other scientists propose that the combination of genes acts synergistically to result in the autism phenotype (Rutter, 2005). However, because monozygotic twins are not 100% concordant for diagnosis, and especially not for severity of diagnosis, factors other than genetics must be involved (Rapin & Tuchman, 2008).

Environmental influences in autism. Many non-genetic factors have been implicated in autism including, but not limited to, intra-uterine toxins (e.g., maternal hypothyroidism, cocaine or alcohol use), birth order effects, obstetric complications, social class and race, measles-mumps-rubella vaccinations, and the vaccination preservative, Thimerosol. Although the media widely publicized some of these factors, epidemiological studies provide no support for a causal relationship between any of these factors and autism (Rutter, 2005). There is preliminary support that immunological dysfunction may have a causal influence in a subgroup of individuals with autism. Although this theory is under active investigation in humans and animal models, it remains speculative at this time (Rapin & Tuchman, 2008). However, there is consensus that it warrants further investigation (Johnson & Myers, 2007; Rutter).

Neuro-biological basis for autism. Brain imaging, post-mortem examinations and electrophysiology have been used extensively to investigate potential neurological influences in autism. Despite significant research attention, no defining pathophysiological mechanisms have been revealed thus far, and many studies have included small sample sizes and have not been consistently replicated (Moldin, Rubenstein & Hyman, 2006). Courchesne and colleagues (2007) point out that most of the neuro-biological research in autism has taken place with adolescents or adults, decades after the initial clinical onset of autism, and may not provide a true picture of what happened in the early developing brain of an individual with autism. It is likely that many of the documented neuro-biological changes apply to only a small subset of individuals with autism (Courchesne et al.).

The most consistently reported anatomical abnormalities in the brains of individuals with autism involve the cerebellum and limbic system (Bauman & Kemper, 2005). Specifically related to the cerebellum, the most-notable, well-replicated, neuro-anatomical finding is deficiencies in the numbers of Purkinje cells (Bauman & Kemper, 1995; Kemper & Bauman, 1998; Rapin & Katzman, 1998). Since Purkinje cells help to regulate arousal by dampening stimulation to the reticular activating system of the brain stem, a decrease in Purkinje cells could result in oversensitivity to input (Kandel, Schwartz & Jessell, 1995, as cited in Mailloux, 2001; Reeves, 2001a).

In individuals with autism, cells in the amygdala and hippocampus of the limbic system are atypically small but more numerous and densely packed than expected (Bauman & Kemper, 2005). The amygdala is most often considered to be involved in behavioural manifestations of autism (Rapin & Tuchman, 2008). The hippocampus plays a role in learning and memory by habituating to stimuli and inhibiting the amygdala and reticular formation so one can focus on a task (Miller-Kuhaneck & Glennon, 2001).

In a review of the literature on brain growth and autism, Courchesne and colleagues (2007) report early brain overgrowth, especially in the frontal lobes, temporal lobes and amygdala, followed by a slowing or arresting of brain growth in early childhood. The brain overgrowth may be due to increased neuron formation, which could produce an imbalance in excitatory and inhibitory influences (Courchesne et al.; Rubenstein & Merzenich, 2003). This overgrowth occurs during developmentally critical years, and may impact the neural systems involved in language, social, emotional and attentional skills, resulting in the clinical onset of autism. This picture of brain growth fits with the current emphasis in neuro-biological research in autism, which has moved away from the focus on discrete neuro-anatomical abnormalities to abnormal development of neuronal connectivity. Specifically, current research supports pervasive long-distance neuronal under-connectivity, affecting sensory and information processing and integration (Minshew & Williams, 2007; Rapin & Tuchman, 2008). Low-level, basic information processing is typically intact. However, because of the lack of neuronal connectivity, this information is not integrated and used to support higher-order, goal-directed behaviours (Courchesne, Redcay, Morgan & Kennedy, 2005). The current model of autism, focusing on neuronal connectivity, and the resulting deficits in sensory and information processing, fits nicely with the concepts surrounding differences in sensory processing in autism.

Differences in Sensory Processing in Individuals with Autism

Unusual sensory symptoms, such as hyper-reactions to typically non-noxious auditory or visual stimuli, are frequently reported in individuals with autism, although they are not a defining feature of the disorder. Dawson and Watling (2000) reviewed the research literature, first-hand accounts of autism, and clinical descriptions of autism, and reported that between 30% and 100% of individuals with autism have some manifestations of atypical sensory processing. More recently, a critical review of sensory processing in autism (Rogers & Ozonoff, 2005), including parent reports, observation and physiological indicators, confirmed that symptoms of atypical sensory processing are indeed more frequent and prominent in children with autism than typically developing children. Atypical sensory symptoms, however, are not unique to autism as they are also common in children with fragile-X syndrome and those who are deaf and blind (Rogers & Ozonoff). A meta-analysis of parent-reported sensory symptoms in individuals with autism confirmed that children with autism demonstrate atypical sensory symptoms more frequently than chronologically and mental-age matched peers, especially related to under-responsivity to sensory input (Ben-Sasson et al., 2009). Atypical sensory symptoms peaked between 6 and 9 years of age, and were related to severity of autism as symptoms were more common in individuals with autism than in individuals with ASD.

Differences in sensory processing in individuals with autism are not typically due to structural deficits in the sensory organs themselves, but rather to difficulties deriving meaning from sensory information (Dunn, 2000). Difficulties responding to sensory input with behaviour that is appropriate to the type and intensity of the sensory input are assumed to reflect poor modulation of inhibitory and excitatory functions of the central nervous systems (Baranek, 2002). This difficulty regulating behavioural responses to sensory input in a graded and adaptive manner is described as *sensory modulation dysfunction* (Miller, Anzalone, Lane, Cermak & Osten, 2007). If one’s ability to modulate sensory input is compromised, behaviour and learning will be compromised (Huebner & Dunn, 2001). For example, sensory modulation dysfunction can contribute to anxiety, abnormal activity levels, low frustration tolerance, deficits in social participation, and attention problems, thus interfering with a child’s participation in activities of daily living (Bar-Shalita et al., 2008; Degangi, 2000).

Different types of sensory modulation dysfunction have been identified to help interpret behaviour and guide intervention planning (Huebner & Dunn, 2001). Sensory over-responsivity represents an increased response to sensory input compared to the response of individuals with typical sensory modulation. An individual with sensory over-responsivity could respond with more intensity, duration or speed than expected given the type and magnitude of sensory input. For example, a child may refuse to wear certain types of clothing because the tactile sensation from tags or the fabric is perceived as too uncomfortable. Sensory under-responsivity represents a decreased response to sensory input compared to the response of individuals with typical sensory modulation. Someone with sensory under-responsivity may generate a response that is not proportionate to the magnitude of the stimulation. For example, a child may fall and cut himself, but not respond to the painful stimulus (Miller et al., 2007). It is possible for an individual to demonstrate fluctuating levels of sensory responsivity within and between sensory systems (Tomchek, 2001). Although a child's behaviour may appear willful, responses due to sensory modulation dysfunction are automatic, unconscious, physiologic responses to sensation (Miller et al.).

Sensory Modulation Dysfunction, Arousal, and Behaviour

Part of the typical adaptive response to sensory input includes maintaining an appropriate level of arousal, or general state of excitation of one's nervous system (Huebner & Dunn, 2001; Kandel et al., 2000). Atypical responses in individuals with sensory modulation dysfunction, including over- and under- behavioural responses to sensory input, can be associated with over- and under-arousal (Miller & Lane, 2000; Tomchek, 2001). Individuals with autism are thought to have a very narrow range of optimal arousal (Baranek, Reinhartsen & Wannamaker, 2001).

Difficulties with levels of arousal are not surprising given that many areas of the central nervous system (CNS) involved in arousal are implicated in autism. Arousal is modulated by the reticular formation of the brainstem, which filters relevant information about sensory input to higher levels of the brain (Saper, 2000). In turn, these higher brain structures, including the amygdala and limbic system, work through the hypothalamus to coordinate autonomic functions and behavioural responses (Iversen, Iversen & Saper, 2000). The autonomic nervous system (ANS) regulates an individual's ability to react and adapt to their environment (Schaaf, Miller, Seawell & O'Keefe, 2003). This is achieved through integrative functioning of two ANS branches: 1) the sympathetic nervous system (SNS), which modulates immediate responses to events (e.g., fight or flight reactions) and, 2) the parasympathetic nervous system (PNS), which maintains homeostasis and regulates recovery from a stressor (e.g., rest and digest). For simplicity, these branches are discussed and measured in isolation, although any effect actually represents a balance of activity between the SNS and PNS, and both branches communicate with the CNS (Iversen et al., 2000). Increased SNS activity and/or decreased PNS activity can correspond with increased arousal, and decreased SNS activity and/or increased PNS activity can correspond with decreased arousal. For example, a child who is over-responsive to sensory input will feel overwhelmed by the variety of sights, sounds and physical bumping and jostling that occurs during an assembly at school. His nervous system will perceive the environment as "dangerous", activating arousal and the "fight or flight" mechanisms of the sympathetic nervous system. Due to the sympathetic response, attention will be focused on the "dangerous" aspects of the environment, and not on adaptive behavioural responses that promote attention to the assembly activities. In a child with a typically developing nervous system, his PNS will increase activity to decrease arousal so he can achieve a state of physiological homeostasis and focus on the meaningful activities of the assembly.

Studies involving physiological measures have shown that the ANS in children with sensory modulation dysfunction, including children with autism, responds differently than expected. Althaus and colleagues (2005) found that children with autism have decreased parasympathetic activity compared with typically developing children during attention demanding tasks. Miller and colleagues found that children with sensory modulation dysfunction and no other medical diagnosis demonstrate reduced parasympathetic activity (Schaaf, Miller, Seawell and O'Keefe, 2003), and demonstrate either significantly lower or significantly higher sympathetic activity compared with typically developing peers (McIntosh, Miller, Shru & Hagerman, 1999).

They suggest that the variable pattern of sympathetic response indicates a difference in ANS activity in both over- and under-responding to sensory input in children with sensory modulation dysfunction. Additionally, children with fragile-X syndrome who displayed behavioural indicators of sensory over-reactivity also had increased sympathetic nervous system activity, suggesting that over-arousal to sensation might contribute to maladaptive behaviours associated with sensory modulation dysfunction (Miller et al., 1999). These authors suggest that children with autism display a dysfunction in SNS activation and sensory modulation similar to children with fragile X syndrome.

Although theories of hyper-arousal in autism are prominent (e.g., Belmonte et al., 2004; Bryson, 2005; Goodwin et al., 2006; Liss, Saulnier, Fein & Kinsbourne, 2006), and the physiological research summarized above provides support for over-arousal in autism (MacIntosh et al., 1999; Miller et al., 1999), a recent meta-analysis (Ben-Sasson et al., 2009) and critical review of the literature (Rogers & Ozonoff, 2005) both concluded that hypo-arousal and under-responsivity are the most unique and prominent types of sensory modulation dysfunction in individuals with autism. However, Rogers and Ozonoff note that the evidence-base from which these conclusions were drawn had significant methodological issues. While Ben-Sasson and colleagues found the greatest differences in individuals with autism in under-responsivity, differences were also noted in over-responsivity. Therefore, it appears that individuals with autism demonstrate difficulties with both over- and under-responsivity, and over- and under-arousal. Regardless of the type of sensory-modulation dysfunction, the goal of sensory-based intervention is to normalize arousal to facilitate attention and enhance learning (Royeen & Lane, 1991, as cited in Huebner & Lane, 2002).

Attention and autism

Deficits in attention are commonly reported in individuals with autism, and are often suspected to be associated with sensory modulation dysfunction. Kientz and Dunn (1997) reported attention difficulties in 75% of children with autism compared to only

3% of typically developing children. Mayes and Calhoun (2007) reported significant attention problems in 93% of children with autism. In one study, up to 60% of children with ASD met criteria for attention deficit hyperactivity disorder (Albores-Gallo, Hernández-Guzmán, Díaz-Pichardo, Cortes-Hernández & Hasfura-Buenaga, 2009). There is no clear picture of attention difficulties in individuals with autism, as children with autism demonstrate both over-focused attention and extreme distractibility.

Many individuals with autism have difficulty disengaging attention from one stimulus to focus on another stimulus (Bryson, 2005). In fact, a child's failure to respond to their name when absorbed in an activity is one of the best early markers of autism (Baranek, 1999; Robins, Fein, Baron & Green, 2001). In a longitudinal study examining early behavioural manifestations of autism, Zwaigenbaum and colleagues (2005) found that infants with more difficulties disengaging attention at 12 months old, relative to their own performance at 6 months old, were more likely to receive an ASD diagnosis at 24 months old. They speculated that this decreased ability to disengage visual attention may relate to development of the pre-frontal cortex, which fits with current models of brain growth and connectivity (e.g., Courchesne et al.; Rubenstein & Merzenich, 2003). Mayes and Calhoun (2007) noted that, although children with autism were highly distractible, most of the children in their sample could remain hyper-focused on self-selected activities that were of interest to them, such as spinning the wheels on toys for hours. Liss and colleagues (2006) hypothesized that over-focused attention is a coping strategy used by over-aroused individuals with autism to block out extraneous stimuli and allow them to focus on predictable events to help modulate their arousal level.

Selectivity of attention can also be an issue. Using functional imaging techniques, Belmonte and colleagues (2004) found that individuals with autism demonstrated equal attention to all stimuli, regardless of its location, behavioural relevance, or sensory modality. They suggested that the absence of a mechanism to bias attention towards relevant stimuli creates a "processing bottleneck" because an individual cannot select between competing sensory inputs. They hypothesized that the overload of sensory input resulted in over-arousal in some individuals with autism. Greenaway and Plaisted (2005) noted that individuals with autism demonstrate intense focus on static items, such as the wheels of a toy, but have difficulty attending to dynamic stimuli, such as that found in social situations and school classrooms.

In summary, individuals with autism as a group demonstrate both over-focused attention, including an inability to disengage visual attention, and extreme distractibility. These different types of attention difficulties can occur in the same individual, depending on the types of activities and environment, and can interfere significantly with a child's ability to function in everyday environments, such as school. Many authors hypothesize that attention difficulties are rooted in difficulties modulating sensory input to maintain functional levels of arousal.

Stereotyped Behaviours in Autism

Stereotyped or repetitive behaviours are one of the core features in autism included in the DSM-IV-TR diagnostic criteria and assessed on the Autism Diagnostic Observation Scale-Generic (ADOS; Lord et al., 2000) and the Autism Diagnostic Interview-Revised (ADI-R; Rutter, Le Couteur & Lord, 2003), which are currently viewed as the "gold standard" in autism diagnosis (Reaven, Hepburn & Ross, 2008). Stereotyped behaviours typically refer to repetitive movements or behaviours that do not appear to serve an adaptive function (Baumeister & Forehand, 1973, as cited in Kennedy, Meyer, Knowles and Shukla, 2000). The behaviours are very heterogeneous, and can be verbal or nonverbal, fine or gross motor in form, or involve complex routines and rituals (Cunningham & Schreibman, 2009). Common examples of stereotyped behaviours include, but are not limited to, hand flapping, finger flicking, body rocking, sniffing and scratching objects, spinning objects, running objects or one's fingers across their field of view, and immediate and delayed echolalia (APA, 2000; Schreibman, Heyser & Stahmer, 1999, as cited in Cunningham & Schreibman, 2009). There are many theoretical viewpoints on the function of stereotyped behaviours. The most widely accepted theories are homeostatic and operant functions (Cunningham & Schreibman, 2009; Willemsen-Swinkels, Buitelaar, Dekker & van Engeland, 1998). A third, less widely discussed theoretical basis for stereotyped behaviours is that they are based on underlying pathology.

The homeostatic theory of stereotyped behaviours assumes that the behaviours can increase or decrease a child's arousal levels in response to over- or under-stimulating environments. This theory has many supporters (e.g., Liss et al., 2006; Soussignan & Koch, 1985; Willemsen-Swinkels et al., 1998). Soussignan and Koch found that rhythmical stereotyped movements (leg-swinging) reduced physiological arousal, as measured by decreased heart rate, in typically developing children. Willemsen-Swinkels and colleagues also used heart rate to investigate a homeostatic theory of stereotyped behaviours in 14 individuals with ASD. They divided the function of stereotyped behaviours into three categories based on observation of mood and behaviour while engaged in the stereotyped behaviour. These categories were distress, composure (calm), and elation. Children with ASD demonstrated composure and elation with relatively similar frequencies (137 and 147 instances respectively), and behaviours associated with distress less frequently (83 instances). Stereotyped behaviours associated with distress and composure tended to be repetitive and low-intensity (e.g., making sounds, intense visual examination of object, rocking), whereas stereotyped behaviours associated with elation tended to be short duration and involve movement of the limbs (e.g., hand flapping, hand and finger mannerisms). Heart rate peaked prior to, but dropped during and following, stereotyped behaviours that were associated with distress, supporting a homeostatic function of behaviour. Behaviours associated with composure did not affect heart rate. The authors hypothesized that these behaviours may have served a homeostatic function by counterbalancing under-stimulation. However, they also proposed that these behaviours may be used to gain attention from others. Behaviours associated with elation also did not affect heart rate, and were speculated to serve as an outlet for excitement.

The second prominent theory of the function of stereotyped behaviours is based on operant behavior, meaning that the stereotyped behaviours are maintained by the direct reinforcement they provide (Cunningham & Schreibman, 2009). This reinforcement often involves direct sensory input (e.g., visual and proprioceptive stimuli from finger mannerisms, auditory stimuli from humming, proprioceptive stimuli from tapping), but can also involve social reinforcement, such as attention from others or escape or avoidance of aversive stimuli (Willemsen-Swinkels et al., 1998). Behaviours that serve a sensory function are often referred to as 'self-stimulatory' behaviours. This function of stereotyped behaviours is strongly supported, although the underlying mechanisms are not yet understood (Cunningham & Schreibman).

The third, less widely discussed theory is that stereotyped behaviours are neurologically based, and therefore neither adaptive nor functional, but maintained by underlying pathology (Lewis, Baumeister & Mailman, 1987). Dopamine, which plays a role in emotion, attention and arousal, is most commonly implicated (Reeves, 2001a). Children with more severe psychomotor symptoms have shown increased dopamine levels (Tsai, 1999), and dopamine receptor antagonists (e.g., risperidone, haloperidol) have decreased stereotyped behaviours in some children with autism (McDougle et al., 1998; Cohen et al., 1980, as cited in Palermo & Curatolo, 2004). Stereotyped behaviours can be induced by drugs that increase the transmission of dopamine. However, it appears that the types of stereotypic behaviours induced by drugs are not qualitatively the same as the behaviours that occur spontaneously in children with autism. Therefore, it is speculated that stereotyped behaviours in children with autism are supported by different mechanisms or motivations (Mink & Mandelbaum, 2006).

Regardless of their cause, stereotyped behaviours can directly interfere with learning and participation in even simple daily functions (Baranek, Foster & Berkson, 1997), and the suppression of stereotyped behaviours has been associated with increased responding and participation in activities (Morrison & Rosales-Ruiz, 1997). Therefore, interventions that decrease stereotyped behaviours can have important implications in the day to day lives of children with autism.

Dunn's Model of Sensory Processing

Dunn (1997) proposed a model of sensory processing consistent with concepts of sensory modulation dysfunction, which enables a more precise understanding of how individual responses to sensory input at the neurological level influence behavioural responses within the context of everyday activities. In this model, a neurological continuum represents the amount of sensory stimulation one's nervous system requires to respond. A high neurological threshold indicates that a lot of sensory stimulation is required before the nervous system responds; therefore, individuals with a high neurological threshold might under-respond to their environment, and might be under-aroused. Alternatively, a low neurological threshold indicates that little sensory stimulation is required before the nervous system responds. Individuals with a low neurological threshold are likely to over-respond to their environment, might be over-aroused, and may appear easily distracted. A behavioural response continuum reflects the strategies someone uses to manage their own needs and preferences. People may be passive responders, where they just let things happen to them, or active responders, where they behave purposefully in response to their thresholds.

Four sensory processing patterns represent how the intersection between neurological and behavioral continua affects one's responses in everyday life. A *registration* pattern represents a high neurological threshold with passive response patterns. Therefore, this person needs a lot of input for his nervous system to notice, but does not do anything about it. The person with a registration pattern might miss cues in his environment, and may appear uninterested, withdrawn or self-absorbed. Clear instructions and salient cues might increase participation in educational activities. A *seeking* pattern represents a high neurological threshold with active response patterns. This means that this person needs a lot of input for his nervous system to notice and actively seeks extra sensory stimuli in an attempt to get to an optimal state of arousal for learning and attention. A seeker might touch or tap items, chew on things, move around a lot and fidget. He may require frequent breaks or novel educational activities to maintain interest and focus. A *sensitive* pattern represents a low neurological threshold and passive behavioural response. Therefore, this person needs very little sensory stimuli to notice, and does not take significant measures to reduce extraneous stimuli. This person may appear distracted and complain that stimuli are bothersome, and may be helped by structured, predictable activities. The final sensory processing pattern, *avoiding*, represents a low neurological threshold and active behavioural response. This person needs very little sensory input to notice, and takes an active role in reducing stimuli. He may take significant measures to reduce extraneous stimuli, and may be rule-bound and ritualistic, or move away from bothersome activities (Dunn, 1997, 2001, 2006; Huebner & Dunn, 2002). An individual can demonstrate definite differences from typical in more than one pattern of sensory processing (Dunn, 2006). For example, someone may be sensitive to sounds, but seek movement. No one sensory processing pattern is any better or worse than another; rather, the impact of any particular sensory processing pattern will depend on the individual, the environment and the task demands (Dunn, 2001).

The validity and reliability of Dunn's model of sensory processing has been tested with individuals with and without disabilities, including autism, across the lifespan. Four standardized assessments, based on Dunn's model have been used in research. There are three assessments designed for caregivers to complete: Short Sensory Profile (McIntosh, Miller, Shyu & Dunn, 1999), Infant/Toddler Sensory Profile (Brown & Dunn, 2002), and Sensory Profile (Dunn, 1999) for ages 3 to 10. Additionally, the Adolescent/Adult Sensory Profile (Dunn, 2002) is designed for the individual with sensory processing differences over age 10 to complete, and the Sensory Profile School Companion (Dunn, 2006) is for teachers of children ages 3 to 11 to complete. Each of these questionnaires asks questions, rated on a 5-point Likert scale, about how an individual might respond to sensory events in everyday life. The Short Sensory Profile provides a total score, and includes those items most representative of sensory modulation dysfunction. Scores obtained on the other measures address the four quadrants represented in Dunn's Model of Sensory Processing. Although Dunn's Model of Sensory Processing is often used in research (Ben-Sasson et al., 2009), the primary purpose of the model is to help understand the meaning of behaviours from a sensory processing perspective to guide intervention (Dunn, 1999).

Interventions to Address Sensory Modulation Dysfunction in Autism

Sensory modulation dysfunction has pervasive effects on adaptive behaviour and participation in daily activities. Therefore, interventions to decrease the effects of sensory modulation dysfunction have important implications for improving the quality of life of individuals with autism and for lessening the burden of care for parents and caregivers of children with autism. Indeed, strategies to address sensory modulation dysfunction are the most frequent occupational therapy recommendation for children with autism across settings (Case-Smith & Miller, 1999; Watling et al., 1999).

The types of interventions used by occupational therapists to support participation of children with autism and sensory modulation dysfunction in classroom settings are broad, and can include remediation, education and modification (Baranek, 2008). Traditional sensory integration treatment is a remedial approach, which assumes that prescribed sensory experiences can enhance neural processing resulting in improved adaptive behaviours (Baranek). Although there are still many supporters of traditional sensory integration theory and treatment, more recent conceptualizations of sensory processing stress the influence of factors external to the child and suggest treatment strategies beyond remediation. For example, Dunn (1997, 1999, 2002) stresses the importance of adapting activities and environments whenever possible. Baranek and colleagues (2001) recognize that sensory thresholds are one variable that impacts a child’s ability to engage with his or her environment, but that a variety of other factors intrinsic and extrinsic to the child will also impact a child’s ability to engage functionally in everyday activities and environments. For example, engagement depends on motivation, cognition and physical characteristics of the activity and the environment in which the activity occurs. Therefore, Baranek (2001, 2008) stresses the need to provide intervention beyond remediation that includes task and environmental adaptations and accommodations related to a child’s sensory preferences or avoidances. Miller and Summers (2001) discuss the Ecological Model of Sensory Modulation, a conceptual model linked directly to persons with autism and other developmental disorders. They propose that four external dimensions (culture, environment, relationships and task) interact with three internal dimensions (sensory processing, emotions, and attention) to contribute to adaptive behaviour problems associated with sensory modulation dysfunction. They highlight the need to consider all seven dimensions during assessment and intervention with children with autism and sensory modulation dysfunction. However, they acknowledge that much of the occupational therapy literature has not emphasized the importance of ecological factors related to sensory modulation dysfunction. Rather, this area of practice has focused on components such as sensory responses.

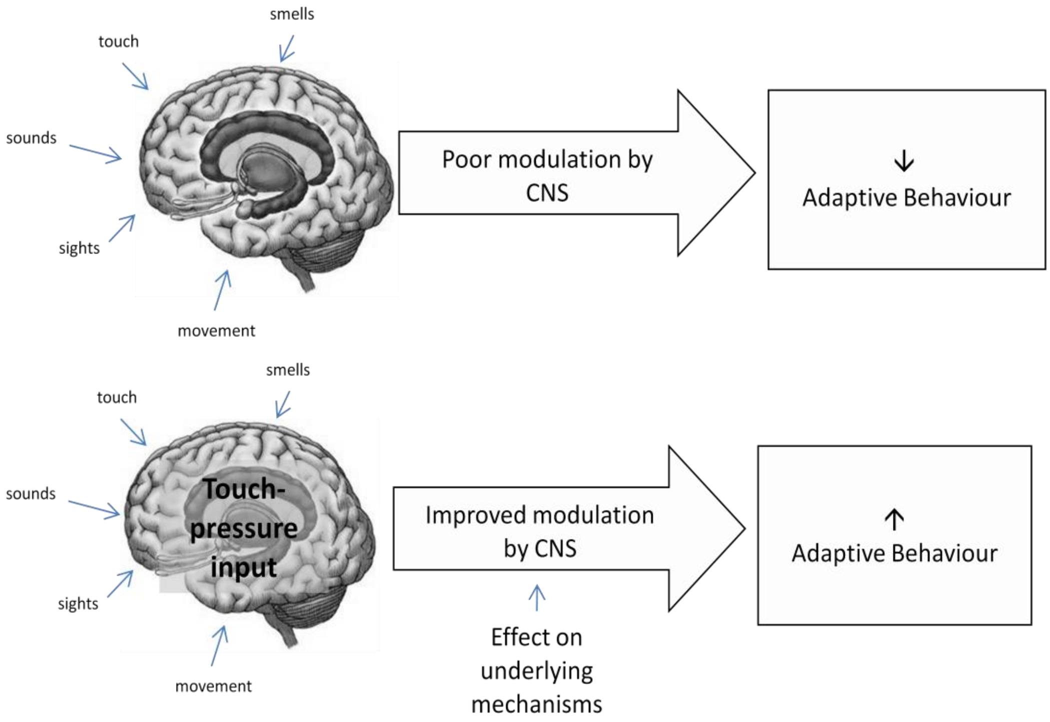
Remedial approaches are widely used by occupational therapists and other professionals (Miller & Summers, 2001). One specific remedial technique to decrease sensory modulation dysfunction within the context of daily activities is the passive application of sensory stimulation. Weighted vests are frequently used by occupational therapists who work with children with autism as one modality to provide direct firm tactile and proprioceptive sensory input (Olson & Moulton, 2004a, 2004b). The tactile and proprioceptive input provided by weighted vests is referred to clinically as deep touch-pressure input, referring to a somatosensory sensation somewhere between light, barely perceptible sensation and heavy, deep and painful sensation (Krauss, 1987). Sensory stimulation strategies, including weighted vests, are based on the theory that touch-pressure input can decrease sensory modulation dysfunction by changing levels of arousal in the central nervous system, thereby resulting in positive behavioural and functional outcomes (Anzalone & Murray, 2002; Huebner & Dunn, 2001; Rogers & Ozonoff, 2005).

Most supporters of the use of touch-pressure input for arousal modulation believe that touch-pressure input is appropriate for over-responses to sensory input. For example, Dunn (2006, 2007) recommends touch-pressure input for individuals with a low neurological threshold, proposing that touch-pressure input provides organized, calming input to the nervous system, without generating additional arousal. Huebner and Kraemer (2001) suggest that touch-pressure input can be calming whether passively applied (e.g., weighted vest) or actively stimulated (e.g., proprioceptive input from pushing against resistance). Unlike the pathways for light touch, pain, head movement and sound, the pathways that carry information about touch-pressure input do not extend collateral fibres to the reticular formation as they traverse the brainstem (Reeves, 2001a). Rather, touch-pressure input travels from the medulla to the thalamus and somatosensory cortex, where it, according to sensory stimulation theory, is able to reduce excitability and decrease arousal by providing descending inhibitory control on the reticular formation through reciprocal pathways (Reeves). Therefore, touch-pressure input is thought to exert a regulatory influence over other sensory inputs, as well as a regulatory influence on arousal level in general (Blanche & Schaaf, 2001; Reeves, 2001b).

One specific mechanism suggested to decrease arousal, resulting in improved adaptive behaviour, is increased activity in the PNS (Lane, 2001; Schaaf et al., 2004; VandenBerg, 2001). Increased PNS activity has been linked to increased alertness, attention span, and performance on cognitive tasks in neuro-typical persons (Porges, 1997, as cited in Field, 1998; Field et al., 1997). The specific neural pathways that link touch-pressure input with increased PNS activity have not been measured directly, nor are they well articulated in the literature. Massage therapy, which provides touch-pressure input, has decreased hyperactivity, off-task behaviour and stereotyped behaviours in two randomized controlled trials with children with autism (Escalona, Field, Singer-Strunck, Cullen & Hartshorn, 2001; Field, Lasko, Henteleff, Kabat, Talpins, & Dowling, 1997). Studies have confirmed that massage therapy increases PNS activity in cocaine exposed infants (Field, 1990, as cited in Field et al., 1997) and decreases arousal when moderate to firm pressure is used, as measured through EEG activity and overall heart rate, in neuro-typical adults (Diego, Field, Sanders & Hernandez-Reif, 2004). However, no studies have directly investigated the effects of any touch-pressure intervention on brain function or PNS activity in children with autism. The general theoretical basis for the use of interventions that provide touch-pressure input is provided in Figure 1.

Several authors have stressed the need for systematic research that investigates the efficacy of strategies that involve touch-pressure input, including weighted vests. In particular, the need for research that includes understanding both underlying neurophysiologic mechanisms and behavioural outcomes has been highlighted (e.g., Baranek, 2002; Dawson & Watling, 2000; Rogers & Ozonoff, 2005).

Figure 1. Theoretical basis for interventions that provide touch-pressure input.



Sensory input is poorly modulated at the level of the nervous system, which leads to difficulties with adaptive behaviour. Touch-pressure input is thought to improve sensory modulation by changing levels of arousal in the nervous system through effects of underlying mechanisms. Improved sensory modulation translates into improved adaptive behaviour.

Review of Research on Weighted Vests and Sensory Modulation Dysfunction

Practice Trends with Weighted Vests

Olson and Moulton (2004a) surveyed 340 pediatric occupational therapists by mail about their experiences with weighted vests and their impressions of the vests' effectiveness in changing specific behaviours. Respondents indicated that vests were most commonly used with preschool and elementary school aged children. Autism spectrum disorder was the most frequent diagnosis, with 82% of respondents having used weighted vests with this population. The most commonly targeted behaviours included staying on task, staying in seat and increasing attention span. Practice trends varied greatly: 62% of respondents reported most frequently using two pounds of weight (range 1 to 5+ pounds), 73% of respondents reported using the vest for less than one hour per session (range <1 hour to >4 hours), and 34% of respondents reported recommending that a child wear the vest twice per day (range 1 to 4 times/day).

The mail survey conducted by Olson and Moulton (2004a) provided quantitative information about general practice patterns of weighted vest use in pediatric occupational therapy practice; however therapists were not able to elaborate on individual practice patterns. Therefore, Olson and Moulton (2004b) expanded on their initial survey by conducting telephone interviews with a convenience sample of 51 pediatric occupational therapists. These interviews elicited qualitative information about individualized practice patterns and personal opinions about weighted vests based on individual child characteristics. In this self-selected sample, 68% of the respondents worked in school settings and 92% used weighted vests with children with autism. Increases in attention, staying on task and following instructions, and decreases in rocking, tantrums, and wandering were the most commonly reported targeted outcomes for children with autism. Protocols for vest use varied considerably, with the amount of weight often starting low and increasing until a positive effect is seen, up to 10% body weight. The most common response for wearing time was no longer than 30 minutes at a given time. The majority of respondents felt that changes occur immediately upon donning a weighted vest. Vests were most commonly used during academic tabletop activities.

The Edmonton and Area Occupational Therapy Pediatric Interest Group (October, 2005) conducted an informal survey of over 50 members regarding the use of weighted vests in practice. Although a wide range of responses were provided, consensus supported Olson and Moulton’s survey: 1) weighted vests were most frequently used with children with autism spectrum disorders, 2) therapists typically started with 2 pounds of weight and increased up to 5% body weight, although increases up to 10% body weight were noted, and 3) a wearing schedule of no more than 20 minutes at a time was commonly recommended.

These surveys demonstrate that, although weighted vests are frequently used, there is a lack of consistency regarding the amount of weight and wearing schedule. However, there is consensus that weighted vests are a very common recommendation for children with autism and are viewed as beneficial.

Research Specific to Weighted Vests

Relative to their wide-spread clinical use, empirical research related to weighted vest use in children with autism is limited to five peer-reviewed studies, one non-peer-reviewed study, and two poster abstracts. Additionally, there is one peer-reviewed study examining the effects of weighted vests for four children with Attention Deficit Hyperactivity Disorder (ADHD), but no autism diagnosis. A summary of these nine studies is provided in Table 1.

Participant Descriptions. These studies included a total of 21 participants identified with ASD (14 participants with an autism diagnosis, 1 participant with suspected autism, 5 participants with PDD, and 1 participant with developmental delay and autism-like behaviours). Only three studies provided information on how a diagnosis was made (Cox, Gast, Luscre & Ayres, 2009; Kane, Luiselli, Dearborn & Young, 2004-2005; Myles et al., 2004), and none of the participants had a diagnosis confirmed with the ADOS or ADI-R. Participants ranged in age from 2 years to 11 years, with 16 of the 21 participants under age 7. The study of four children with ADHD included information about diagnosis, and the participants were between 3 and 6 years old.

Reported Outcomes. Dependent variables were most often related to on-task behaviour and self-stimulatory or stereotyped behaviours. Overall, reported effects for children with autism or ASD were: increased on-task behaviour (includes attention to task and distractions) in 6 of 14 participants for whom this behaviour was measured;

decreased self-stimulatory or stereotyped behaviour in 6 of 13 participants for whom this behaviour was measured; and no effect for increasing sitting (3 participants), joint attention (1 participant), or decreasing competing (1 participant) or problem (1 participant) behaviours. Increased on-task behaviour was reported in all 4 of the participants with ADHD.

Research Design. All research was single-case design, with an overall positive trend in the strength of the designs used over time. Earlier studies used relatively weak AB (VandenBerg, 2001), ABA (Fertel-Daly, Bedell & Hinojosa, 2001) and ABC (Kane et al., 2004-2005) designs. More recent studies used stronger single-case designs, including ABAB (Myles et al., 2004), multiple-baseline (Stein, 2007), and alternating treatment (Barton, Reichow & Wolery, 2007; Carter, 2005; Cox et al., 2009; Deris, Hagelman, Schilling & DiCarlo, 2006) designs.

Blinding of treatment condition strengthens the confidence one can have in the results of a treatment study because it removes observer expectancy bias. Although weighted vests lend themselves quite easily to blinding, only one study employed blinding of raters to treatment condition, although no details were provided on how blinding occurred (Barton et al., 2007). Interestingly, Barton and colleagues actually presented their study as a double-blind placebo trial to allow for "analysis of the effects of treatment guarding against observer or participant bias". Since the participants, who were wearing the vests, cannot be blinded to treatment condition, it is assumed that it was reported as double-blind because the participants were non-verbal.

Treatment fidelity is an important component of any intervention study. Treatment fidelity (or treatment integrity) refers to the degree to which treatments were implemented as intended during the course of the study (Gresham, 1996). If the protocol of weighted vest use (e.g., timing, amount of weight) is not adhered to the study will have poor internal validity, and it will be impossible to know if an effect was actually due to the weighted vest. Treatment fidelity was only reported in the Cox et al. (2009) study.

Inter-rater reliability is also an important component of single-case research because it controls for observer bias and drift with observational data. Inter-rater reliability was reported in all of the studies except Kane et al. (2004-2005). Although frequently reported, the quality of reliability checking was lower in four studies. For example, Fertel-Daly and colleagues (2001) only included reliability checks during the baseline phase; therefore, observer drift may have influenced the results, especially since the rater was not blinded to treatment condition. VandenBerg (2001) reported conducting checks with two raters prior to the study. However, since one person rated during the baseline condition and a different person rated during the intervention phase, inter-rater reliability checks were not actually conducted during the study. Myles and colleagues (2004) conducted a series of three case-studies, yet only reported adequate reliability for one participant. Encouragingly, there was a trend towards improved rigor in inter-rater reliability checks over time (e.g., occurrence and non-occurrence agreement were often reported in more recently published studies). No studies reported Kappa co-efficient, even though this has been "demonstrated to be a superior index of inter-observer agreement and should be the default measure in behavioral research (Watkins & Pacheco, 2001, p. 211).

Weighted Vest Protocol. Consistent with Olson and Moulton's (2004a; 2004b) findings of no standard protocol for weighted vest use in clinical practice there was no standard protocol for weighted vest use in research. In seven of nine studies reviewed, the amount of weight ranged from 5-10% body weight. Fertel-Daly and colleagues (2001) used only one pound of weight regardless of the weight of the participant. They determined that weighted vests were effective in decreasing the number of responses to distractions and increasing attention to task for all five participants in their study, and in decreasing the duration of self-stimulatory behaviours in four out of five participants during a table-top, fine motor activity. They did note that the smallest participant demonstrated the greatest decrease in number of distractions, suggesting that a higher proportion of body weight may result in greater effects. Across the nine studies, the wearing schedule ranged from 5 minutes to 2 hours, with 20-30 minutes being most common. Vests were worn only once per day in eight of nine studies.

Observation Protocol. Details of the observation protocol were described in seven of nine studies. Observations occurred for 5 to 15 minutes each time. Observations occurred within the first minute of donning the vest in three studies. Observations occurred after the vest had been worn for a short period of time (5 and 15 minutes) in two studies, and after the vest had been worn for a longer period of time (30 and 90 minutes) in two studies.

Summary of Research Findings. Overall, positive effects were noted in three of nine studies, for a total of 7 children with autism and 4 children with ADHD (Fertel-Daly et al., 2001; Myles et al., 2004; VandenBerg, 2001). However, these studies had many methodological limitations. For example, both Fertel-Daly and colleagues and VandenBerg used weak research design, and therefore positive results cannot be separated from potential confounding variables. Issues with inter-rater reliability further decrease confidence in the results of these studies. Myles and colleagues (2004) used a more rigorous ABAB design, which decreases the impact of potential confounding variables. However, as discussed by Stephenson and Carter (2009), the data presented in the graphs is not in line with the text. Therefore, the positive results cannot be confirmed with visual inspection of data.

The authors of the other six studies, with a total of 13 participants, concluded that weighted vests were ineffective and should not be recommended in clinical practice, at least until rigorous research is available to the contrary. Although these studies had fewer methodological problems than Fertel-Daly and colleagues (2001) and VandenBerg (2001), there were still many methodological weaknesses. Stephenson and Carter (2009) summarized their thorough review of the literature related to weighted vest use in children with autism with the following statement:

> There may be an arguable case for continued research on this intervention but future investigators need to ensure that: criteria for participant selection are replicable and justifiable; participants are adequately described; inter-observer reliability is satisfactorily established; observers are blinded to the presence of weight in the vests; results are appropriately interpreted with consideration of the

> functional magnitude of changes; and more stringent research designs are employed (p. 112-113).

I agree with Stephenson and Carter's conclusions that the current state of research does not provide empirical support for the use of weighted vests in clinical practice. Although there has been an increase in the number and quality of studies on the effectiveness of weighted vests in recent years, the available research is still not methodologically strong enough to provide conclusive evidence on the effects of weighted vests for children with autism. This study addresses methodological concerns of previous studies, and aims to provide meaningful information to research and clinical communities by systematically investigating behavioural and physiological effects of weighted vests for children with autism in the classroom setting.

Purpose of the Proposed Study

The primary propose of this study was to systematically investigate the effects of weighted vests on classroom behaviour for children with autism. An additional purpose of this study was to test the theoretical assumptions upon which sensory strategies are based by linking the use of weighted vests to heart rate, an indicator of nervous system function. We hypothesized that: 1) touch-pressure sensory input applied through a weighted vest would result in decreased off-task behaviour, increased sitting time, and decreased stereotyped behaviours in all participants, 2) heart rate would decrease during weighted vest use, and 3) teachers and educational assistants would indicate that weighted vests were acceptable tools for use in conjunction with other strategies to enable children with autism to function more productively in school environments.

Table 1. Summary of research on weighted vests for children with autism.

Citation	Source	Age	Design	N	Protocol	Outcomes Measured	Reported findings
Fertel-Daly et al. (2001)	Refereed article	2 - 4 years	ABA	5	1 lb in all vests; worn for 2 hours; 5 minute observation after vest worn for 1.5 hours	Attention to task, number of distractions, self-stimulatory behaviours	Decrease in number of distractions, increase in attention to task, decrease in self-stimulatory behaviours
Myles et al. (2004)	Refereed article	3 - 6 years	Series of 3 separate ABAB	3	5-10% body wt.; Part. 1 & 2: worn and observed 5-10 min. (duration of activity) Part. 3: worn for 30 min. before 15 min. observation	On-task behaviour (participants 1 & 2); Self-stimulation - seeking deep pressure touch (participant 3)	Participant 1: No effect; Participant 2: 25% increase in time on-task; Participant 3: 13% decrease in time of self-stimulation
Kane et al. (2004-2005)	Refereed article	8 - 11 years	ABC (no vest; wt. vest; vest no wt.)	4	5% body wt; 10 minute observation; vest on 1 minute prior to observation	Attention to task, stereotyped behaviours	No positive effects. Weighted vest appeared to have negative influence with 3 participants
Carter (2005)	Refereed article	4 years	Alternating treatment (no vest, wt. vest, vest no wt.)	1	7.5 % body weight; worn during 5 minute observations	Self injurious behaviour	No effect
Deris et al. (2006)	ERIC document (non-refereed)	4 years	Alternating treatment (no vest, pressure vest, wt. vest)	1	10% body weight; 30 minute increments, every 2 hours during school day; data collected for 10 min. after wearing vest for 15 min.	Attention to task, self-stimulatory behaviour	No effect
Barton el al. (2007)	Poster	4 years	Alternating treatment (no vest; wt. vest; vest no wt.)	2	Details not provided	Part. 1: engagement; Part. 2: engagement, problem behaviour, stereotyped behaviour	Part. 1: No effect; Part 2.: problem behaviour increased, stereotyped behaviour decreased, and no effect on engagement with weighted vest

Stein (2007)	Poster	2 years	Multiple baseline	2	5% body weight; worn 20 minutes daily during play session	Joint attention, competing behaviour (sensory behaviours that interfered with activity participation)	No effect
Cox et al. (2009)	Refereed article	5 - 9 years	Alternating treatment (no vest; vest no wt.; wt. vest)	3	5% body weight; Worn for 30 minutes, 1x/day; Data collected for first 10 minutes	Duration of in-seat behaviour	No effect
VandenBurg (2001) *ADHD	Refereed article	5 - 6 years	AB	4	5% body weight; Worn for 20-30 minutes, 1x/day; 15 minute observation began after vest on for 5 minutes	On-task behaviour	On-task behaviour increased by 18-25% in all participants

CHAPTER II: METHODS

Participants

Recruitment and Enrollment

Participants were recruited from two Edmonton Public School Board (EPSB) Early Education programs and one EPSB Interactions program, which is specifically for children diagnosed with autism.

Recruitment Procedures. Ethical approval was obtained through the Health Research Ethics Board (HREB – Panel B) at the University of Alberta. Administrative approval was obtained from the Cooperative Activities Program (CAP), University of Alberta, a requirement for any research within educational settings in Edmonton (see Appendix A). I met with the EPSB Director of Occupational Therapy and occupational therapists who worked in the Interactions and Early Education programs in greater Edmonton to identify the most appropriate sites. The criteria were the number of possible children and consistency of occupational therapists, teachers and aides. Following in-person meetings to explain the study in detail, approval was obtained from the appropriate administrative personnel at the sites in which the research took place, the classroom teachers, the classroom occupational therapist, and the classroom/child aides.

A recruitment poster and response form (Appendix B) was sent home with all children with autism in the participating classrooms. All children in the Interactions program had a diagnosis of autism; therefore, letters were sent home with all students (n=10). Early Education classrooms do not require a diagnosis of autism. Therefore, teachers identified appropriate children based on a diagnosis of autism, and letters were sent home with those students (n=6). One participant, who was fully integrated into a mainstream classroom at the same school as the Interactions program, was included at the request of his teacher. Parents interested in having their child participate in the study returned the form to the classroom teacher, indicating that they were interested in more information. The researcher then sent an information letter and proxy consent form to interested parents (Appendices C and D respectively). This was followed by a meeting with the parents at a location of their choice (home or school) to obtain written consent, complete a screening tool (Short Sensory Profile), a general family information form (Appendix E) and to answer any questions prior to beginning the study.

Inclusion/exclusion criteria. Participants met the following criteria:

1. diagnosis of autism, confirmed by the Autism Diagnostic Observation Scale (ADOS, Lord et al., 2000) or Diagnostic and Statistical Manual of Mental Disorders criteria (DSM-IV, APA, 2000), if ADOS scores were not available;
2. between 3 and 10 years old, reflecting common practice with weighted vests. The wide age range was not a concern because this study tested the response of each individual, rather than a group of individuals;
3. difficulties with attention to task during activities, in comparison to children without autism of a similar age, based on verbal report by their teacher;
4. an attendance record of at least 3 days/week over the previous month;
5. had a consistent individual or classroom aide for the duration of the study to implement the intervention;
6. one parent who read English well enough to complete the measures and give consent;
7. a total test score more than 2 standard deviations below the mean on the Short Sensory Profile (McIntosh et al., 1999a) indicating definite sensory modulation abnormalities; and
8. not using a weighted vest at other times during the study. For example, some participants had concurrent home-based intervention programs including occupational therapy consultation.

   Weighted vest use prior to the study was not an exclusion criterion since the effects were not expected to last for any significant period beyond the time the child was wearing the vest.

Thirteen of seventeen parents to whom recruitment letters were sent initially indicated an interest in the study. One child did not meet eligibility criteria because he exceeded the upper age limit. One child began the baseline phase, but moved to a new school after one week. A third child completed 5 weeks of data collection but the intervention was discontinued because he immediately took off the vest and heart rate monitor each day starting in week 4. Additionally, he had three different aides from weeks 3 to 5.

Participant Descriptions

In single-case research design, sample size is defined by the number of observations rather than number of subjects as used in group designs. Therefore, the number of participants is small, while the number of observations for each participant is relatively large. This study included ten participants. This number allowed for randomization of phases within and between classrooms, and controlled for potential attrition. A summary of participant characteristics is provided in Table 2. All assessment information was from the child's school file and assessments were completed within the past two years. Information came from speech-language pathology (language), psychology (adaptive functioning and cognition) and occupational therapy (motor skills) assessments. No formal assessments were completed by the researchers.

Participant 1 - Adam. Adam was eight years old at the start of data collection. He was diagnosed at the age of 2 years, 3 months, by a multi-disciplinary assessment team using the ADOS - Module 1. He was assessed as having a severe cognitive delay (Bayley Scales of Infant Development, 2nd edition; BSID-II) and colitis (inflammation of the gastro-intestinal tract). Earlier speech and language testing revealed a severe language delay (Preschool Language Scales, 3rd edition), and Adam was non-verbal with no functional communication system at the time of the study. He lived with both parents. His mother graduated from high school, and did not work outside the home. His father had a professional diploma and worked in management. English was spoken at home. Adam received home-based services, including 6 hours/week of developmental aide support and 4 hours/month of occupational therapy consultation. No changes in services occurred during the study, and no weighted items were used at home. He took Nalcrom for allergies and Clonidine for insomnia with no changes in dose during the study. Adam was in a segregated classroom with seven other children with autism, one teacher and four aides. He required an individual aide at school to participate functionally in activities, for self-care activities, and to remain seated. When left on his own, Adam would leave the classroom or shake objects.

Participant 2 - Bobby. Bobby was 6 years, 6 months old at the start of data collection. He was diagnosed at the age of 2 years, 7 months, by a multidisciplinary assessment team using the ADOS - Module 1. Cognitive assessment scores were not available. Scores on the Vineland Adaptive Behaviour Scale (second edition) revealed an overall moderately-low adaptive behaviour composite, with relative strengths in motor skills (average range), and relative weaknesses in socialization, communication and daily living skills (all in the extremely low range). Bobby was non-verbal with no functional communication system. He was in a segregated classroom with seven other children with autism, one teacher and four aides. He required an individual aide at school to participate functionally in activities, for self-care activities, and to remain seated. When left on his own, Bobby would run from the classroom, or self-stimulate with objects by tapping and shaking them. He lived with his mother; his father lived in another city. Both Bobby's parents had graduate-level degrees, and worked outside the home. English was spoken at home. Bobby was not receiving home-based services. He took Clonidine for insomnia and attention/hyperactivity and Risperidone for aggression and disruptive behaviour, with no changes in dose during the study.

Participant 3 - Connor. Connor was 10 years, 1 month old at the start of data collection. He was diagnosed at 4 years of age by a multidisciplinary assessment team using DSM-IV criteria (APA, 2000). He was assessed as having a severe cognitive delay (Wechsler Intelligence Scale for Children, 3rd edition). Connor made requests and answered questions using short sentences. He lived with both parents, and two siblings. Connor's mother completed high school and his father completed university. Both parents worked full-time outside the home. English was spoken at home. Connor was not receiving home-based services or taking any medication. He was in a segregated classroom with five other children with autism and/or language delay, one teacher and two classroom aides. Connor was integrated into a mainstream classroom for music and gym. When left on his own, he had significant delayed echolalia, repeating phrases from movies or videogames. Connor was able to don and doff his own vest with a verbal reminder.

Participant 4 - David. David was 5 years, 7 months old at the start of data collection. He was diagnosed at 2 years, 6 months by a multi-disciplinary assessment team using the ADOS - Module 1. Cognitive assessment scores were not available. David had emerging verbal skills, including babbling, counting and identifying some letters. He could make requests using Picture Exchange Communication System and could follow one step directions well. He lived with both his parents, who each had a professional diploma and worked full-time outside of the home. English was spoken at home. David took no medications. He received concurrent home-based services including 15 hrs/week of developmental aide, four hours/month of speech-language pathology consultation, and two hours/month of occupational therapy consultation. No changes in his home program occurred during data collection. David was integrated into a mainstream kindergarten class every morning with the assistance of an individual aide. He required an aide to focus on all activities. Without the aide, he would wander around the classroom or stare into space.

Participant 5 - Evan. Evan was 4 years, 1 month at the start of data collection. He was diagnosed at age 3 years, 8 months, by a multidisciplinary assessment team using the ADOS - Module 1. Cognitive assessment scores were not available. Evan was identified with severe language delay (Preschool Language Scales, 4th edition; PLS-4), and did not have functional language but did have some immediate echolalia. He lived with both parents and an infant sibling. Evan's parents were both typically employed full-time outside the home, although his mother was home on maternity leave. Both parents had professional diplomas. English was spoken as a second language at home. Evan did not receive home-based services at the time of the study. He did not take any medication. Evan was in a segregated early intervention classroom every weekday afternoon with eight other children with autism and/or language delay, one teacher, one speech language pathologist, one part-time occupational therapist, and two classroom aides.

Participant 6 - Fabian. Fabian was 6 years old at the start of data collection. He was diagnosed at age 5 years, 5 months by a multi-disciplinary assessment team using the ADOS – Module 1. He was also assessed with a severe fine motor delay (Peabody Developmental Motor Scales, 2nd edition; PDMS-II), a severe communication disorder (Rossetti Infant-Toddler Language Scale, severe receptive and expressive), severe cognitive delay (BSID-III; Wechsler Preschool and Primary Scales of Intelligence, 3rd edition) and extremely low adaptive behaviour (Adaptive Behaviour Assessment System, 2nd edition; ABAS-II; general and all composite scores). Fabian had no functional language. Fabian's parents were divorced. He lived with his mother and sister. His mother worked part-time from home. His father had an elementary school education and worked in manual labor. Fabian was in a segregated early intervention classroom every weekday afternoon with eight other children with autism and/or language delay, one teacher, one speech language pathologist, one part-time occupational therapist, and two classroom aides. Fabian received no home-based services at the time of the study.

Participant 7 - Grace. Grace was 3 years, 7 months at the start of data collection. She was diagnosed at age 3 years by a multi-disciplinary assessment team using the ADOS – Module 1. She was also assessed with severe cognitive delay (BSID-III), moderate fine motor delay (PDMS-II), and severe language delay (Receptive and Expressive Emergent Language Scales, 3rd edition). Grace was able to label items, repeat phrases and make some basic requests. She lived with both her parents and two younger siblings. Her mother stayed home and her father worked part-time in retail and took English language courses part-time. Grace's mother had a working knowledge of English, however English was not spoken in the home. She was able to complete the Short Sensory Profile with minor clarification for some words. Grace was in a segregated early intervention classroom every weekday morning with eight other children with autism and/or language delay, one teacher, one speech language pathologist, one part-time occupational therapist, and two classroom aides. Grace did not receive any home-based services.

Participant 8 - Hailey. Hailey was 3 years, 11 months at the start of data collection. She was diagnosed at 22 months by a multi-disciplinary assessment team using the ADOS – Module 1. She was assessed with a severe receptive and profound expressive speech and language delay [Functional Communication Profile (FCP); Communication and Symbolic Behaviour Scales – Developmental Profile]. She was non-verbal. Hailey lived with both her parents and one older sibling. English was spoken at home. Her mother had a high school diploma and worked part-time outside the home. Her father had a professional diploma and worked full-time outside the home. Hailey took Melatonin to help her sleep, and took two doses of Prozac each day (1 mg every morning and afternoon). There were no changes in medication during the study. Hailey was in a full-time, classroom-based, early intervention program specific to children with autism. This program included consultation from a speech-language pathologist and an occupational therapist. There were three other children in her classroom, each with an individual aide. Hailey received monthly home-based consultation from her school-based team.

Participant 9 - Ian. Ian was 5 years, 6 months old at the start of data collection. He was diagnosed at age 2 years, 10 months by a multi-disciplinary assessment team based on DSM-IV criteria. Psychological assessment revealed extremely low adaptive function across domains (ABAS-II). He was also assessed with severe fine motor delay (PDMS-II), severe expressive and receptive language delay (PLS-4), and was non-verbal. A pediatric psychiatrist diagnosed Ian with a severe anxiety disorder two months prior to participation in the study. He took no medication. Ian lived in an English speaking home with both parents and an older sibling. His mother had a university degree. She did not work outside of the home at the time of the study. His father had a professional diploma and worked full-time outside of the home. Ian was in a full-time, classroom-based, early intervention program specific to children with autism. There were three other children in his classroom, each with an individual aide. This program included consultation from a speech-language pathologist and an occupational therapist. He received monthly home-based consultation from his school-based team. His mother reported that he used an eight pound weighted blanket at home to sleep, and frequently asked for deep pressure to the extent that she could put her full body-weight on him. Based on his desire for a lot of deep pressure, Ian's mother did not think 5% body weight would be effective. To test the hypothesis that increased body weight would be more effective for Ian, 10% body weight was used during the second weighted phase.

Participant 10 - Jack. Jack was 6 years, 4 months old at the start of data collection. He was diagnosed at the age of 2 years, 9 months by a multi-disciplinary assessment team using the ADOS - Module 1 and ADI. He was also assessed with extremely low adaptive function (ABAS-II; general adaptive composite and all adaptive domains) and a severe language and communication delay (MacArthur Communicative Development Inventories; FCP). He was non-verbal and had no functional communication system. Jack lived with his mother, who had a graduate degree and worked full-time outside of the home. His father lived in another city. English was spoken in the home. Jack took Clonidine for attention/hyperactivity, with no changes in dose during the study. He was in a full-time, classroom-based, early intervention program specific to children with autism. There were three other children in his classroom, each with an individual aide. This program included consultation from a speech-language pathologist and an occupational therapist. He received monthly home-based consultation from his school-based team. Jack's mother did not think 5% body weight would be enough, so increased weight (10% body weight) was used during the second weighted phase.

Summary of Participants. In summary, participants included 8 boys and 2 girls between the ages of 3-10 years. Most of the children were non-verbal (n=7) and 3 children had echolalia, but no functional language. Four children had verified severe cognitive delays, and psycho-educational assessment for three children speculated severe cognitive delays because standardized testing could not be completed, even below age level. Based on the level of adaptation required for educational activities and the level of support required for activities of daily living, it can be concluded that the other 3 children also had significant cognitive delays. Most of the children received a diagnosis of autism as part of a multidisciplinary assessment that included the ADOS (n=8). All of the children required aide support at school.

Table 2. Summary of participant characteristics

Child	Age	Gender	Age at Diagnosis	Weight - lbs (wt. in vest)	Cognitive/ Adaptive Functioning	Language
Adam	8-0	Male	2-3	49 (2 ½)	Severe cognitive delay	Severe delay Non-verbal
Bobby	6-6	Male	2-7	63 (3 ¼)	Moderate/low adaptive functioning Cognitive not available	Non-verbal
Connor	10-1	Male	4-0	120 (6)	Severe cognitive delay	Delayed echolalia
David	5-7	Male	2-6	38 (2)	Not available	Non-verbal
Evan	4-1	Male	3-8	40 (2)	Not available	Severe delay Limited echolalia
Fabian	6-0	Male	5-5	55 (2 ¾)	Severe cognitive delay Extremely low adaptive functioning	Severe delay Non-verbal
Grace	3-7	Female	3-0	50 (2 ½)	Severe cognitive delay	Severe delay Echolalia
Hailey	3-11	Female	1-10	43 (2 ¼)	Cognitive could not be completed	Severe delay Non-verbal
Ian	5-6	Male	2-10	50 (2 ½; 5)	Extremely low adaptive functioning Cognitive could not be completed	Severe delay Non-verbal
Jack	6-4	Male	2-9	68 (3 ½; 6)	Extremely low adaptive functioning Cognitive could not be completed	Severe delay Non-verbal

There were a total of five different classrooms, and therefore five different teachers gave consent to participate in this study. There were 9 aides who gave consent to participate in this study. Fabian and Grace had the same aide because they attended the same program but Grace attended in the morning and Fabian attended in the afternoon. Table 3 summarizes teacher involvement and classroom set-up for each participant.

Table 3. Teachers and classrooms involved in the study

Teacher	Children	Classroom Information
1	Adam Bobby	Segregated elementary classroom for children with autism with individual aides for participants
2	Connor	Segregated elementary classroom for children with autism with partial inclusion with aide support; 2 classroom aides (consistent aide with Connor)
3	David	Integrated kindergarten classroom with aide support for David
4	Evan Fabian Grace	Segregated preschool program for children with severe developmental delays; 2 classroom aides and full-time speech and language pathologist in classroom
5	Hailey Ian Jack	Segregated preschool program for children with autism, individual aides

Descriptive Measures

Short Sensory Profile

The Short Sensory Profile (SSP) is a norm-referenced tool, with good internal validity, designed for research and screening purposes (McIntosh et al., 1999a). The 38-items on the SSP are taken from the Sensory Profile (Dunn, 1999) and were chosen because they are the items that most strongly discriminate children with and without sensory modulation dysfunction. Therefore, participants included in a study based on atypical SSP scores are very likely to have sensory modulation dysfunction.

Parents completed this 38-item questionnaire, requiring 10 minutes, as part of the screening process for participants. Children had to score at least 2 standard deviations below the mean, indicating a definite difference in processing of sensory information compared with typically developing peers. A score between 38 and 141 (out of 190) is within the “definite difference” range, with lower scores indicating more severe sensory modulation difficulties. Table 4 provides a summary of the SSP scores for each participant.

Table 4. Short Sensory Profile total scores

Child	Overall Score
Adam	141
Bobby	118
Connor	140
David	138
Evan	141
Fabian	118
Grace	132
Hailey	127
Ian	129
Jack	127

Sensory Profile School Companion

Each child’s aide completed the 62-item Sensory Profile School Companion Teacher Questionnaire (Sensory Profile – SC; Dunn, 2006) if it had not already been completed within the school year. For six participants, this assessment had already been completed by the classroom teacher (at the request of the classroom occupational therapist) within the past school year, and a copy of that assessment was provided. The Sensory Profile – SC, modeled after the Sensory Profile (Dunn, 1999), is appropriate for children ages 3 to 11 years and has been validated as a measure of functional behaviours associated with responses to sensory stimuli, including in individuals with autism. It provides information about the child in the context of his or her classroom, including how the sensory characteristics of situations can be supportive or difficult for a child (Dunn, 2008). Initial content validity was established through interviews with teachers and occupational therapists to ensure that the test items were representative of the full range of sensory behaviours at school and to ensure that items reflected Dunn's Model of Sensory Processing. Initial convergent and discriminant validity was established with the quadrant scores on the Sensory Profile Caregiver Questionnaire (Dunn, 1999). Internal consistency was high (Cronbach's alpha = 0.83-0.95), meaning that items grouped together represent the same concept (i.e., quadrants). Teacher responses on the Sensory Profile-SC were stable across time, indicating good to excellent test-retest reliability (r = .80-.95, 3 weeks apart). Children with autism demonstrated significant differences from their typically-developing peers across all scores (Dunn, 2008). The questionnaire yields four quadrant scores (registration, seeking, sensitivity, avoiding), which are based on Dunn's Model of Sensory Processing, discussed earlier. Preliminary research with students from a typically developing sample, students with attention deficit hyperactivity disorder and students with an autism spectrum disorder (ASD) suggests that scores for students with ASD cluster around the quadrants registration, seeking, and avoiding (Dunn, 2006).

This profile provided another way to describe the children and allow a more detailed analysis of intervention effectiveness based on specific sensory processing patterns. Table 5 summarizes the participants' quadrant scores, and their relationship to student behaviour and function. All except one participant had scores suggesting that they seek sensation and therefore need help staying focused; seven participants had scores suggesting problems engaging because they do not notice sensations. Therefore there was little variability in the scores limiting their utility for post hoc analyses of responses to the vests.

Table 5. Participants' Sensory Profile School Companion scores more than 2 standard deviations from the mean and expected classroom behaviour and function

Child	Quadrants	Interpretation – Behaviours expected based on theory
Adam	Registration	Not engaged because does not notice
	Seeking	Needs help to stay focused
Bobby	Seeking	Needs help to stay focused
Connor	Registration	Not engaged because does not notice
	Seeking	Needs help to stay focused
	Sensitive	Distracted because overly aware
	Avoiding	Distracted because limited tolerance of sensory input
David	Registration	Not engaged because does not notice
	Seeking	Needs help to stay focused
	Avoiding	Distracted because limited tolerance of sensory input
Evan	Registration	Not engaged because does not notice
Fabian	Registration	Not engaged because does not notice
	Seeking	Needs help to stay focused
	Avoiding	Distracted because limited tolerance of sensory input
Grace	Registration	Not engaged because does not notice
	Seeking	Needs help to stay focused
	Sensitive	Distracted because overly aware
	Avoiding	Distracted because limited tolerance of sensory input
Hailey	Seeking	Needs help to stay focused
Ian	Seeking	Needs help to stay focused
Jack	Registration	Not engaged because does not notice
	Seeking	Needs help to stay focused

Dependent Variables and Instrumentation

Behavioural Variables

Three behavioural dependent variables were included as outcome measures depending upon the concerns for each child: off-task behaviour, stereotyped behaviour, and duration of sitting (see Table 6). Off-task behaviour was measured for all children and was defined as a child looking away from the activity or not participating in the intended functional manipulation of materials related to the activity (e.g., lining up markers rather than drawing). Responding appropriately to external prompts (e.g., their name) was not considered off-task behaviour. Off-task behaviours were coded to determine what a child was doing when he or she was off-task. Each participant's coding sheet was individualized to include common reasons he or she was off-task. Stereotyped behaviours were measured for six children and were also defined individually. Behaviours included rocking, hand flapping, flicking objects, spinning objects, odd hand and finger mannerisms, and delayed echolalia. An example coding sheet is provided in Appendix F.

Sitting was defined as a child having any part of his or her buttocks on the seat of the chair. Non-sitting exemplars include sitting on a chair with legs tucked between the chair and buttocks. Sitting was measured for 3 children. It was an issue for Adam but his aide managed this behaviour by positioning herself so that he remained seated during activities. It was not a concern for the other 6 children.

Physiological Variables

This study tested the theoretical assumptions upon which sensory strategies are based by measuring underlying mechanisms. Heart rate is considered a robust measure of general physiological arousal and has been used frequently to measure responses to sensory stimuli in children with autism. Many studies have shown changes in heart rate to be a particularly sensitive measure of arousal in children (Soussignan & Koch, 1985). A decrease in heart rate can be indicative of decreased sympathetic nervous system activity (fight or flight reaction) and/or increased parasympathetic activity. Although individuals with autism demonstrate significant between-subject variability in heart rate, within-subject variability of heart rate is small both at baseline and within-tasks, and increases are expected with physical exertion (Goodwin et al., 2006; Groden et al., 2005). These patterns of response were expected given that autism does not typically affect one's cardiovascular system. Table 6 identifies the 7 children with information on this dependent variable.

Table 6. Dependent variables for each participant

Child	Behavioural Variables	Physiological Variable: Heart Rate
Adam	Off-task Stereotyped mannerism: flicking fidget belt	Measured
Bobby	Off-task Sitting Stereotyped mannerism: hand and finger mannerisms; flicking objects	Measured
Connor	Off-task Stereotypy: delayed echolalia	Not measured - Verbally refused to wear heart rate monitor
David	Off-task	Measured - Removed independently during data collection on four occasions
Evan	Off-task	Measured
Fabian	Off-task	Not measured - Physically resisted heart rate monitor
Grace	Off-task	Measured
Hailey	Off-task Sitting Stereotyped behaviours: hand and finger mannerisms; spinning objects	Measured
Ian	Off-task Stereotyped behaviours: hand and finger mannerisms; flicking objects	Measured
Jack	Off-task Sitting Stereotyped behaviours: rocking, hand flapping	Not measured - Physically resisted heart rate monitor

Inter-rater Reliability

Using video analysis, inter-rater reliability was established on each child for off-task and sitting behaviours. Initial reliability training involved in-person meetings with the researcher and reliability checker to discuss coding procedures, review data collection sheets, review video footage of exemplars and non-exemplars of targeted behaviours, and refine operational definitions of targeted behaviours if required. This was done for each of the ten participants, since definitions of targeted behaviours were individualized. Separate score sheets were used by each rater, and results were compared following independent rating. Practice sessions scoring each targeted outcome occurred until the minimum agreement was reached on three consecutive trials for each targeted outcome and both raters felt confident in all procedures. Videos from the baseline phase (A) were used.

Reliability checks occurred for 40% of the videos, based on the minimum recommendation that 30% of the sessions or days involve reliability checks (Bailey & Burch, 2002). Specifically, 2 out of the 5 videos for each child from each B and C phase were viewed, totaling 8 videos per child. Kappa is considered the superior index of inter-rater reliability for behavioural research (Watkins & Pacheco, 2000). The Kappa cut-off for acceptable inter-rater reliability was set at .60 based on the standard that values at or above .60 represent good to excellent agreement (Watkins & Pacheco). When a Kappa co-efficient of less than 0.60 was achieved, the primary rater conducted a second review of the video considering the areas of disagreement. Most of the discrepancies were due to brief behaviours that could have been easily missed; therefore, the primary rater felt confident that the additional review resulted in more accurate data and only the primary rater's scoring was used in the presentation of data.

Sitting was an easily observed behaviour; therefore inter-rater agreement was 100% for the three participants for whom this behaviour was measured and Kappa statistics were not calculated. For off-task behaviours, 64 of 80 individual inter-rater videos had a Kappa exceeding .60, and the average Kappa co-efficient for each participant exceeded .60. Stereotyped behaviours were analyzed in the 4 participants who had this as an identified dependent variable and who had a percentage of non-overlapping data points (PND) > .50 for off-task behaviours (Adam, Connor, Ian, Jack). For these four participants, 27 of 32 individual inter-rater videos had a Kappa exceeding .60, and the average Kappa co-efficient for each participant exceeded .60. Additionally, stereotyped behaviours were analyzed as an independent variable for Jack, with a Kappa co-efficient of .61. "Other" off-task behaviours were coded for the 6 participants who demonstrated a PND > .50 for off-task behaviours, resulting in 8 different behaviours coded. Fifty-six of 64 individual inter-rater videos had a Kappa exceeding .60, and the average Kappa co-efficient for each participant exceeded .60. A summary of inter-rater reliability scores for off-task behaviours is provided in Table 7.

Table 7. Summary of inter-rater reliability statistics

Child	Average Kappa	Range	Category*	# Kappa < 0.60
Adam	Off-Task: 0.72	0.57-1.00	Good	1
	Stereotypy: 0.61	0.29-1.00	Good	3 (0.29; 0.41; 0.49)
	Looking away: 0.70	0.43-1.00	Good	2 (0.43; 0.48)
Bobby	Off-Task: 0.71	0.44-1.00	Good	1
Connor	Off-Task: 0.79	0.67-1.00	Excellent	0
	Stereotypy: 0.85	0.65-1.00	Excellent	0
	Looking away: 0.74	0.37-1.00	Good	2 (0.37; 0.53)
David	Off-Task: 0.85	0.69-1.00	Excellent	0
	Looking away: 0.87	0.46-1.00	Excellent	1
	Playing with materials: 0.92	0.65-1.00	Excellent	0
Evan	Off-Task: 0.65	0.42-0.79	Good	3 (0.42; 0.49; 0.58)
	Looking away: 0.87	0.22-1.00	Excellent	1
	Prompt required: 0.92	0.57-1.00	Excellent	1
Fabian	Off-Task: 0.84	0.62-1.00	Excellent	0
Grace	Off-Task: 0.85	0.58-1.00	Excellent	1
Hailey	Off-Task: 0.78	0.50-1.00	Excellent	1
Ian	Off-Task: 0.65	0.52-1.00	Good	3 (0.52, 0.56; 0.56)
	Stereotypy: 0.78	0.62-1.00	Excellent	0
	Looking away: 0.79	0.43-1.00	Excellent	1
Jack	Off-Task: 0.61	0.49-1.00	Good	4 (0.49; 0.50; 0.55; 0.57)
	Stereotypy: 0.71	0.46-1.00	Good	1
	Looking away: 0.82	0.68-1.00	Excellent	0
	Stereotypy: 0.61	0.38-0.83	Good	2 (0.38; 0.47)

***excellent > 0.75; good .60-.75; fair .40-.60; poor < .40**

Teacher ratings of behaviour

Teacher rating scales provide information about a child in the school setting, and, on average, are more reliable than parent rating scales with regard to hyperactive behaviours (Cordes & McLaughlin, 2004). In addition, a teacher can judge the behaviour of a child in the context of his or her peers (Matson, 2003 as cited in Cordes & McLaughlin, 2004). Teacher impressions of behaviour were measured over the course of the study using the Conners’ Global Index - Teacher (CGI-T; Conners, 1997). The CGI-T includes 10 items that assess restlessness, impulsivity and emotional lability and only takes a few minutes to complete. It has separate norms for boys and girls between the ages of 3 and 17 years. Questions are asked using a four-point scale, including: 0 = not true at all (never, seldom), 1 = just a little true (occasionally), 2 = pretty much true (often, quite a bit), and 4 = very much true (very often, very frequent). The questionnaire yields a total score and two dimension scores: “restless-impulsive” and “emotional lability”. The “restless-impulsive dimension items are related to hyperactivity and inattentiveness, and the “emotional lability” dimension items are related to pronounced emotional reactions such as crying or anger.

Conners’ rating scales are commonly used in research and clinical practice for assessing children's behaviour in the classroom and have been used previously to rate behaviours of children with autism (e.g., Edelson, Edelson, Kerr & Grandin, 1999; Escalona et al., 2001). The CGI-T is sensitive to change over a short duration (e.g., 3 weeks), and is especially useful for repeat administrations (Angello et al., 2003; Conners, 1997, 1999; Grizenko et al., 2004). When frequent assessment (e.g., weekly) is required, reliability is improved with the use of a short scale versus the use of a longer scale (Conners, 1997).

Equipment

Weighted Vests

Weighted vests were available, based on clothing size, from a number of vendors. Vests from FDMT Enterprises (Montreal, Canada) were selected for use. They were made from cotton and denim, with a zipper in the front in addition to Velcro closures on the shoulders and sides. These Velcro closures on the shoulders and sides allowed for standardization of fit (tightness) between participants. Four weight pockets, also with Velcro closures were evenly distributed around the body, with two pockets in front and two pockets in the back. Weights were made of steel shot contained in flat, leather pouches to avoid discomfort when seated.

All participants were fitted for a vest prior to the start of data collection. Vests were fit so the researcher's index and middle fingers fit under the straps on top of the shoulders and under the side Velcro strips (perpendicular to the straps; 2 finger width). Therefore, the vest fit like typical clothing, without confounding results by providing the pressure of tight fitting clothing in addition to the weight. Each child had their own vest so the fitting did not have to be continuously recalibrated and their own set of calibrated weights to eliminate errors in the amount of weight provided throughout the study.

For the baseline and withdrawal conditions of this study, pouches that looked identical to the weight pouches were made by a local company, Innovaid, using small Styrofoam balls (approximately the size of peppercorns) instead of steel shot. This ensured that observers could not determine if a child's vest was weighted based on appearance, which was confirmed by both observers.

Heart Rate Monitor

A Polar Vantage XL heart rate monitor was used (Polar Electro, Inc.). This portable, wireless monitor included a rubber electrode transmitter that fastens to gel pads adhered on a child's chest, and a watch-like receiver. Polar heart rate monitors demonstrate good reliability and validity based on simultaneous comparisons with electrocardiogram data, which is the gold-standard for non-invasive methods of heart rate monitoring (Groden et al., 2005; Kadish et al., 2001). The receiver was within 3 feet of the transmitter to acquire the signal. To avoid interference, equipment used by two or more people was not within 3 feet of one another (Polar Electro, 2006).

Polar heart rate monitors were appropriate for use with children with autism and sensitive to physical exertion and potential physiological effects of touch-pressure input based on a feasibility study completed with eight children with autism. Four children, who participated in an activity that was stable over the one-hour of data collection, all had heart rate responses consistent with the hypothesis that weighted vests can have a calming influence resulting in decreased heart rate. Additionally, the two participants for whom the activity was not stable over the one hour period had an increase in mean heart rate with each phase, consistent with an increase in physical activity. A summary of the feasibility study, including participant characteristics and heart rate data, is presented in Appendix G.

Additional Equipment

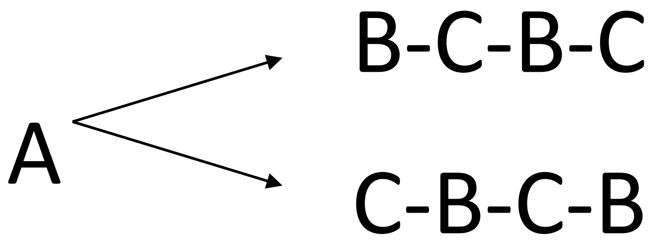
A Timex Ironman stopwatch was used to record duration for data collection. A Gymboss interval timer (www.gymboss.com) was used to signal time sample units for video analysis. JVC hard disk camcorders (GZ-MG130U) were used to record video for behaviour analysis.

Experimental Design

A withdrawal design was used. This design allowed replication of effects within and across participants. Incorporating more than one classroom demonstrated that effects were not limited to a single classroom, specific staff, or a single age group. A withdrawal design is suitable for behaviours that are reversible and where a return to baseline will not cause harm (Barlow & Hersen, 1984). Based on reports of practice trends with weighted vests, it was expected that the behavioural impact of weighted vests would be immediate and temporary. However, Fertel-Daly and colleagues (2001) found that some behaviours for some participants did not completely return to baseline following intervention withdrawal, suggesting there may be short carryover effects. Therefore, phases were changed after a weekend, allowing a two to three day wash-out period between phases.

A typical withdrawal design involves only baseline/withdrawal (A) and intervention (B) phases. However, because we were unaware if the equipment (unweighted vest, heart rate monitoring equipment) would affect a child's behaviours, a baseline phase without equipment was added at the beginning of this study (Phase A). This one-week phase (A) was immediately followed by 2-week phases, B (no weight) and C (weight), which included heart rate measurement for those children who were able to wear the heart rate monitors. The B and C phases were randomly assigned to control for observer bias. The total data collection period was 9 weeks per participant. Figure 2 provides a visual representation of the study design and explanation for each phase.

Figure 2. Study design demonstrating the non-randomized phase A, followed by 4 randomized B and C phases.



A = 1-week behavioural baseline; no vest or heart rate equipment during video

B = 2-week baseline/withdrawal phases; sham weights in vest, heart rate equipment

C = 2 week intervention phase; weighted vest, heart rate equipment

Procedures

Once eligibility was determined, each child was weighed to determine the specific amount of weight to be used in his or her vest. Current clothing size was used to determine individual vest size. The researcher met with each child's aide to train her in the study procedures and met with the child's teacher to identify the best time for vest use and observation of the child. Informed consent from each teacher and aide was obtained during this initial meeting.

Desensitization to Equipment

In order to decrease potential behavioural or physiological stress responses due to the heart rate monitor and/or vest, each participant received his or her vest (unweighted), a heart-rate band and multiple gel pads during phase A. This allowed for desensitization to the equipment through play and practice at school. During phase A, the equipment was not used on a schedule or for any particular activities, and was not used during phase A data collection. Aides were asked not to adjust the fit of the vest, and were provided with a demonstration and handout showing where the gel pads and monitor were placed for the study protocol. Aides were encouraged to allow each child to stick the gel pads on areas other than his or her chest (e.g., on top of clothing, on the hand, on the aide) before sticking the gel pads to the child's chest.

Based on aide report, the vests and heart rate monitors did not appear to impact behaviour on their own. However, one child was distracted by the video camera, frequently looking at and talking to the camera during the first two baseline (A) videos. The video camera was moved to a less obvious location and this behaviour subsided by the third baseline video, and was not a problem in subsequent videos.

Randomization to Treatment Condition

Randomization was done by a researcher not involved in any aspect of data collection or analysis. The initial phase for each participant was determined by flipping a coin with the restriction that there were at least three children in each order. This process resulted in five children using the weighted vest first, and five children using the unweighted vest first. The researcher then wrote the order of phases onto a calendar provided to each aide in a sealed envelope.

Weighted Vest Protocol

Each participant wore the vest for approximately 20 minutes each day at school for phases B and C, at approximately the same time each day. If the activity during which the child typically wore the vest lasted less than 20 minutes the vest was still worn for 20 minutes, continuing into the next activity. Aides reported that on some occasions the vest was worn for up to 30 minutes if the activity in which the child was involved lasted that length of time. Aides did not record which dates this happened; however, it did not correspond with data collection days. Aides were provided with a simple script to use when putting on and removing the vest ("____, it's time to put on/take off your vest"), and were coached not to change the script or tone of voice based on treatment condition. Researchers did not collect video daily, but the routine of wearing the vest daily reflected current practice.

Each child was weighed at the start of the study using a standard, home scale. Weights were calibrated at 5% of the child's body weight. However, as discussed earlier, approximately 10% of body weight was used during the second weighted phases for Ian and Jack, at the request of their mothers. Five percent of body weight was chosen based on current clinical practice. Edmonton area occupational therapists, as part of a pediatric interest group with over 50 members, identified that 5% of body weight is most frequently used as a guideline (September, 2005).

There were no issues related to incorporating weighted vests into the classrooms since it was non-invasive, and did not take the child away from his or her activity. The vest was donned independently by one child (Connor), and by the aide for the other nine participants.

Activities

Each child was observed in his or her classroom during a fine-motor table top activity for which manipulation of an object was required (e.g., drawing, puzzle). This activity was part of the regular curriculum established by the teacher. A summary of the types of activities during which each child was observed is provided in Table 8.

Table 8. Participant activities during observation

Child	Activities
Adam	Matching, sorting
Bobby	Matching, sorting
Connor	Colouring, calendar, worksheets (math, reading)
David	Crafts, colouring, printing
Evan	Crafts
Fabian	Crafts
Grace	Crafts
Hailey	Matching, sorting
Ian	Story workbooks with matching, labeling (by pointing)
Jack	Matching, sorting, functional play with manipulation toys

Behavioural Data Collection

The aim was to have each child video recorded within his or her classroom three times during the baseline week (phase A) and five times during each B and C phases. However, only two baseline videos were obtained for four participants (Evan, Fabian, Hailey, Ian). Video recording was started once the vest was worn for approximately 5 minutes. The rationale for starting data collection after only 5 minutes was based on therapists' clinical perceptions that behavioural effects of weighted vests occur immediately (Olson & Moulton, 2004a, 2004b; Edmonton and area pediatric interest group, 2005). Video recorders were placed on a table, shelf or tripod in the most unobtrusive place possible that allowed for direct recording of the participant while sitting in his or her regular classroom location. Video recording continued until the end of the activity which varied from 15 minutes to 30 minutes. In order to be consistent across participants, only the first 5 minutes of video recording were coded. This resulted in a total of ten, 5-minute videos for each treatment condition (weight or no weight) per child.

Physiological Data Collection

Heart rate data were collected at the same time as behavioural data for the seven participants who wore the heart rate monitor. Heart rate monitors were donned between one and five minutes prior to the vests, allowing time for heart rate to stabilize given the disruption in routine to don the monitor as the child had to go to a private location. Heart rate monitors were started when the vest was donned and time-coded with the video so patterns in heart rate and behaviour could be synchronized. The gel pads and monitor were applied by the child's aide, who was most familiar to the child. The watch portion of the heart rate monitor was pinned on the vest at the back of the child's shoulder so it was not distracting, while keeping it within 3 feet of the monitor to read the signal. The receiver was programmed to record and store heart rate data in 5-second intervals. Heart rate data were transcribed manually, immediately following data collection, onto a Microsoft Excel spreadsheet.

Other Data Collection

Parents, teachers, aides and/or clinical observation by the researcher provided information about potential confounds inherent in the study design (e.g., illness, change in home or classroom routine). No new home-based programs or changes in educational programs were started during the study for any participant. Additionally, educational and home-based programs already established continued throughout the duration of the study.

Teachers completed the Conner's Global Index- Teacher at the end of each two week B and two week C phase and were blind to whether the vest was weighted or had sham weights. Thus, they completed the CGI-T four times over the course of data collection. Teachers were instructed to "consider the last week, when (the child) was wearing the vest" when completing the CGI-T.

Teachers and aides also completed a questionnaire (Appendix H) related to their acceptance of weighted vests and the frequency of their use before the study began and after data collection. Social validity refers to the degree to which a treatment or intervention is deemed important to the participants and consumers of the research. Therefore, social validity is strengthened based on the acceptance of an intervention and the frequency of its use.

Habilitative validity refers to whether or not an intervention is implemented beyond the study period (Kazdin, 2001 as cited in Bailey & Burch, 2002). To assess habilitative validity in this study, the vests were left in the classrooms following completion of the data collection period. The aides and teachers were informed that the vests were left for their use if they desired. Approximately one month following the completion of the study, the vests were picked up by the researcher and the teacher and/or aides were verbally asked if vests had been used since completion of the study. If the vests had been used, details were recorded about when and how they were used. If the vests had not been used, details were asked about why use was not continued.

Treatment Fidelity

Treatment fidelity refers to the degree to which treatments were implemented as intended during the course of the study (Gresham, 1996). In this study, the vests were worn on school days when the researchers were not present for data collection to mimic clinical practice. Aides were the only people with physical contact with the vests; therefore, they were responsible for ensuring that the vest was set to the proper condition (weight/no weight). All aides consistently reported daily implementation of the vest through a checklist provided by the researcher (Appendix I) as a measure of fidelity. Comments were provided for days when the treatment protocol was not followed in whole or in part. Treatment fidelity results are summarized in Table 9.

Table 9. Treatment fidelity

Child	Treatment Fidelity	Reasons for Lack of Fidelity
Adam	92%	Child absent 2 days; aide absent 1 day
Bobby	87%	Forgot 5 days: child absent 2 days; aide absent 2 days; could not sit at all 2 days, so went for walk and did not use vest
Connor	92%	Child absent 3 days
David	55%	Child absent 7 days; aide absent 4 days; aide forgot 4 days; different activity 4 days (assembly; music therapy)
Evan	93%	Child absent 1 day; aide away 1 day
Fabian	89%	Child absent 2 days; aide away 1 day
Grace	83%	Child absent 5 days; aide away 1 day
Hailey	78%	Child absent 6 days
Ian	93%	Child absent 2 days
Jack	96%	Child absent 1 day

Vests were set to the intervention condition (weight/no weight) by the aides prior to each phase, with raters and teachers having no contact with the vests. The researchers verbally reminded the aides to change the condition at the end of each two week phase, while ensuring that the condition was not revealed to the researchers or teachers. The researchers asked for verbal confirmation that the condition had been changed at the start of a new phase. This was not clarified for one participant (David), whose initial phase was postponed by one week due to illness, resulting in a shortened first phase (the aide changed condition as per the original calendar). This was revealed to the researcher after the next phase had been started, without disclosing the treatment condition, so an additional one week phase similar to the first phase was added at the end. This is represented in David's graphs. Aides were coached to not talk about the vests or change their behaviour based on intervention condition.

Data Analysis

Behavioural Observation

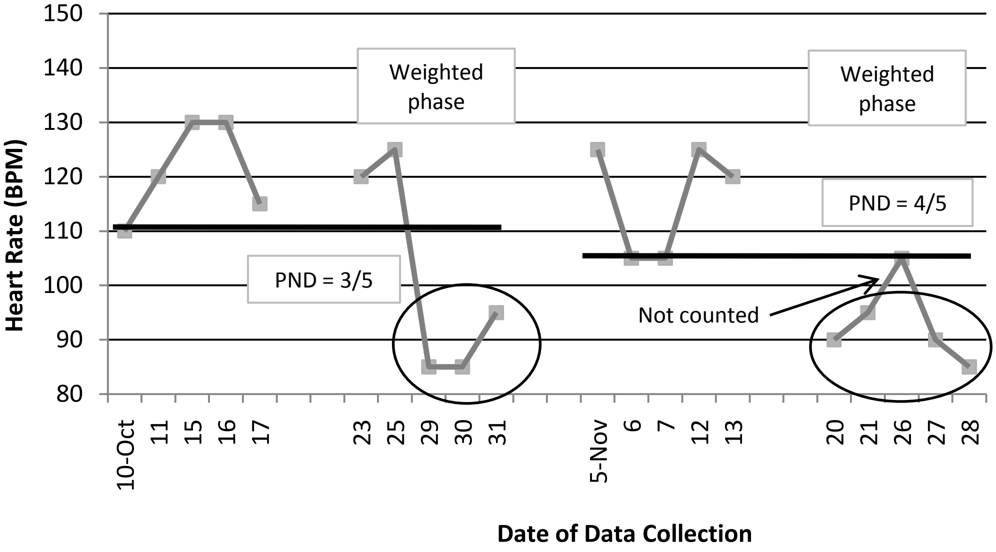
The primary rater, blinded to condition during B and C phases (weight/no weight), collected data for each targeted outcome using continuous observation over the two or three, 5-minute videos for phase A, and the five, 5-minute videos for each B and C phases. Each 5-minute data collection period was divided into 15-second intervals, and the percentage of intervals during which the child demonstrated each targeted behaviour was recorded. If a child demonstrated the targeted behaviour at any point within an interval (once or multiple times), that interval received one checkmark that the behaviour occurred. For example, if 10 of 20 intervals during a 5-minute video received a checkmark for off-task behaviour, that child was engaged in off-task behaviour for 50% of the intervals. This percentage remains the same regardless if the child looked away from the activity one time or ten times in the interval. A Gymboss interval timer was set to indicate each 15-second interval. Observer bias was minimized since observers were blinded to intervention condition.

Traditionally, data analysis in single-case research has used visual inspection of participant responses graphed over time, which has been shown to be highly predictive of statistical significance testing (Bobrovitz & Ottenbacher, 1998; positive predictive value = 0.91). Visual analysis included interpretation of the level (stability of data within and between phases), trend (slope), variability of performance (the degree to which data fluctuates around the mean of a phase) within and between phases, and the immediacy of effects following the introduction or withdrawal of the weighted vest (Horner, Carr, Halle, Mcgee, Odom & Wolery, 2005).

Percent Non-overlapping Data

As an adjunct to visual analysis, statistical indices of the magnitude of effect can be used to provide an objective measure of the effects of an intervention (Parker & Hagen-Burke, 2007). The most commonly recommended statistical index for single-case research is computation of the percent of non-overlapping data (PND) between baseline and treatment phases. PND provides a meaningful interpretation of data by providing cut-scores for treatment effectiveness, and is highly correlated with expert ratings of treatment effectiveness based on visual analysis (Scruggs & Mastropieri, 1998). PND is calculated by dividing the total number of data points in the treatment condition (weight) that do not overlap the data points in the baseline condition by the total number of treatment data points and multiplying by 100. Because weighted vests are intended to decrease off-task behaviour, a line is drawn through the observation of the least magnitude, parallel to the ordinate and extended through the adjacent treatment phase. In withdrawal (i.e., ABAB) design two lines are drawn – one for each baseline phase – and the two PND scores are summed. An example is provided in Figure 3. PND scores of 90% or greater are considered very effective treatment, PND scores of 70-90% are considered effective treatment, PND scores of 50-70% are considered questionable treatment effectiveness and PND scores of less than 50 are considered ineffective treatment (Scruggs & Mastropieri, 1998). PND scores were calculated for all behavioural and heart rate data. When a treatment phase score was equal to the non-treatment phase comparison score, that score was not counted, providing a conservative estimate of PND (see arrow in Figure 3). Only B and C phases were used to calculate PND statistics.

Figure 3. Example of percent non-overlapping data (PND) calculation for mean heart rate.



PND = [(3 + 4) / (5 + 5)] x 100 = 7/10 x 100 = 70%

Unlabeled phases represent the unweighted baseline phases (B). Treatment phases (C) are labeled as "Weight". In this example, there are 3 out of 5 treatment phase data points that do not overlap with the lowest baseline data point for the first pairing, and 4 out of 5 treatment data points that do not overlap with the lowest baseline data point for the second pairing. This totals 7 out of 10 data points for a PND of 70%.

Interpretation of Phase 'A' Data.

Phase A data were only used to visually evaluate potential positive or negative effects of the equipment alone when interpreting and discussing the data in Phase B (unweighted vest). This phase was not long enough to establish a true baseline. Therefore, Phase A data were considered in relation to Phase B data once raters were unblinded to treatment condition to see if there was a marked difference between the phases, which could indicate that the vest and/or heart rate monitor alone impacted behaviour. Phase A data were not used when determining treatment effects based on visual analysis and PND statistics.

Physiological Data: Heart Rate

PND calculations were also done with heart rate data, using the mean heart rate for each day. Additionally, standard deviation of heart rate was calculated for each child for each day the heart rate monitor was worn to determine if there was a difference in the variability of heart rate between baseline and treatment phases. Mean and standard deviation were appropriate measures of variability because the heart rate data were normally distributed.

Scatter plots with trend lines were created with the heart rate data for all treatment (weighted) phases for all participants. This was done to determine if heart rate may have shown a meaningful change if heart rate had been collected for a longer period of time. R-squared values were calculated as a measure of the strength of the predicted direction of the trend line.

Teacher Measures

Raw scores from the CGI-T were converted to standard scores (mean=50, SD = 10). A T-score of 50 is considered average behaviour for a child without autism of the same age and gender. Higher T-scores (and raw scores) are associated with a greater frequency and/or number of problem behaviours. Conners (1997) suggests that T-scores higher than 65 are indicative of a clinically significant problem. Changes in T-scores of 5 or more points are viewed as significant treatment effects (Conners). CGI-T results were not biased by phase as each teacher was blinded to condition.

CHAPTER III: RESULTS

We hypothesized that: 1) touch-pressure sensory input applied through a weighted vest would result in decreased off-task behaviour, increased sitting time, and decreased stereotyped behaviours in the participants, 2) teachers would perceive behavioural benefits of weighted vests, 3) heart rate would decrease with weighed vests, and 4) teachers and educational assistants would think that weighted vests were acceptable tools for use to enable children with autism to function more productively in the classroom.

The following results are presented to address our hypotheses: (1) behavioural data for each child as appropriate, including off-task behaviour, sitting time and stereotyped behaviours; (2) objective teacher ratings of behaviour; (3) physiological data for the seven participants for whom heart rate was collected; (4) a summary of social and habilitative validity surveys; (5) subjective feedback from aides (not blinded to treatment condition), and (6) an overall summary of results.

Behavioural Data

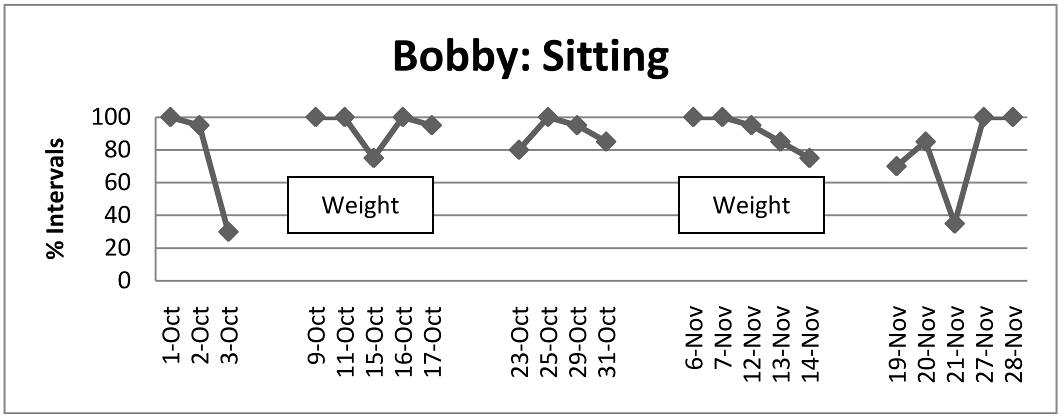
Behavioural data are presented with individual graphs for each targeted outcome for each participant. Graphs depict the percentage of 15-sec. intervals within a 5-min., structured, table-top activity during which the behaviour occurred. If an effect was seen for off-task behaviour based on a PND statistic of 50% or greater, a chart is included with more specific, coded, off-task behaviours. Although stereotyped behaviour was coded independently as a targeted behaviour, initial analysis revealed that all participants except for Jack were always off-task when engaged in stereotyped behaviour. Therefore, stereotyped behaviour is presented under the coding for off-task behaviours in the results for all participants. Jack demonstrated stereotyped behaviours while off-task and on-task. Therefore, stereotyped behaviours are also presented in a separate graph for Jack and were observed independent from off-task behaviour.

For the graphed behavioural data, the first phase always represents the baseline (phase A), before vests and the heart rate monitor were introduced, followed by the treatment-withdrawal (BCBC/CBCB) phases. The “C”, or treatment phase, is indicated on the graph with a “weight” label. Phases without labels indicate a “B” phase, with an unweighted vest. For sitting time, an increase in the targeted behaviour is the desired response. For off-task and stereotyped behaviours, a decrease in the targeted behaviour is the desired response.

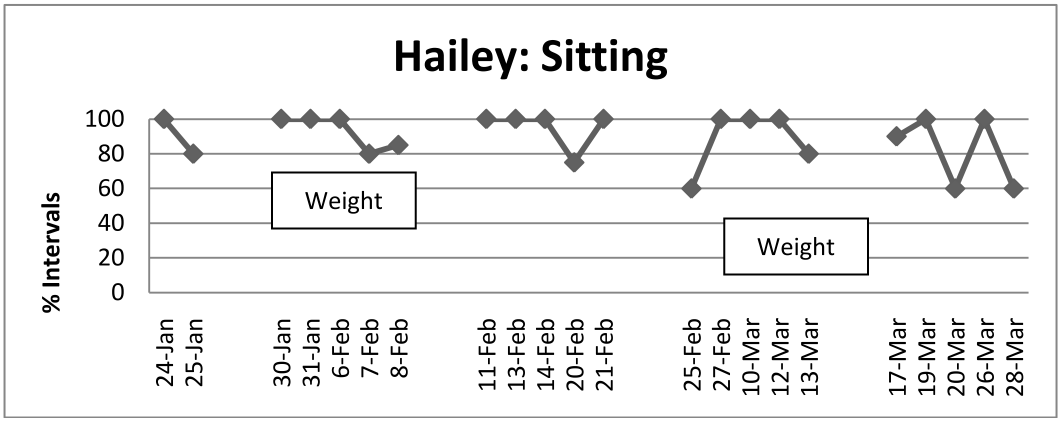
Sitting

The graphs in Figure 4 display the data for the effect of the weighted vest on sitting time during each 5-minute structured table-top activity for each of three children for whom sitting was measured: Bobby, Hailey and Jack. Visual inspection of the graphs and PND statistics suggest that the weighted vest was not effective in improving sitting time for any of the three children. Bobby and Hailey both had variable rates of sitting throughout the study. The weighted vest did not decrease variability in sitting time. Jack also had a lot of variability in sitting. Based on visual analysis, the weighted vest appeared to improve Jack’s sitting for the first weighted phase but this effect was not maintained for the second weighted phase when there was a greater proportion of his body’s weight in the vest.

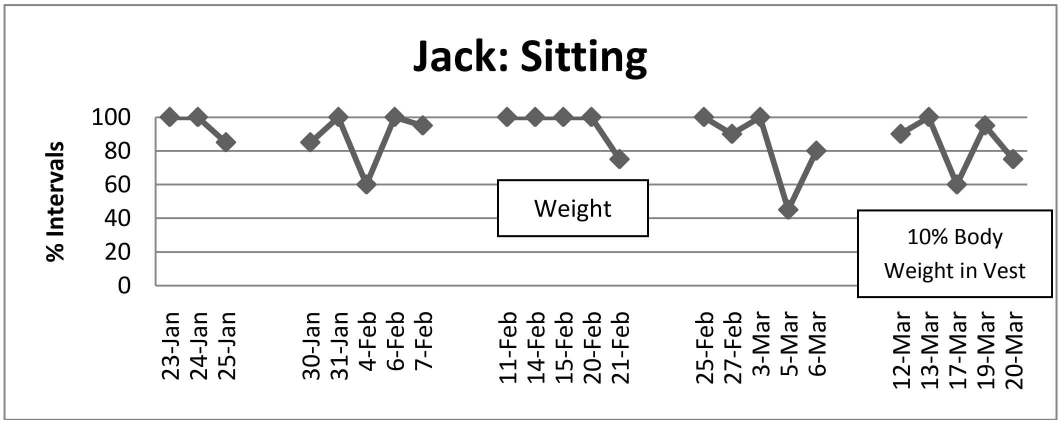
Figure 4. Sitting duration for Bobby, Hailey and Jack.



PND = 0%



PND = 0%



PND = 0%

Sitting duration is expressed as the percentage of 15-second intervals during which the child remained seated within a 5-minute structured, table-top activity each day of data collection. The first phase represents baseline A, without the vest or heart rate monitor. The remaining unlabeled phases represent the unweighted B phases. C phases are labeled as Weight. Five percent body weight was used in all weighted phases unless otherwise indicated. The highest point in each B phase was used to calculate PND because an increase in sitting duration was desired with the treatment.

Off-Task Behaviour

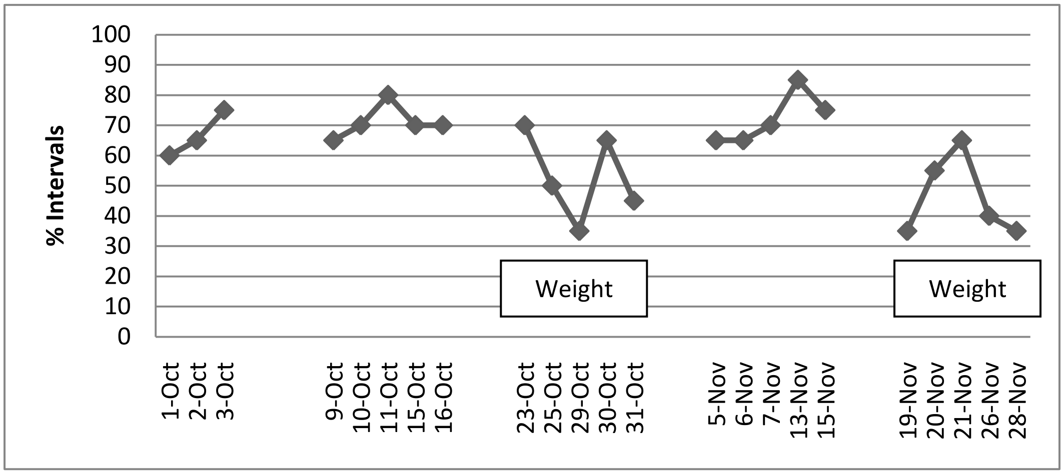
The graphs in Figures 5-14 display the percentage of 15-second intervals that each participant was off-task during the 5-minute tabletop sessions. Visual analysis of the graphs and PND statistics suggest that the weighted vest was effective in decreasing off-task behaviours for 3 of the 10 children (Adam, Connor, Evan), and ineffective in decreasing off-task behaviour for 4 children (Bobby, Fabian, Grace, Hailey). For one participant (Ian), the unweighted vest and/or heart rate monitor appeared to have a negative effect based on his Phase A data and the weighted vest appeared effective in decreasing behaviours back to baseline, but no more so than no intervention at all. For Jack, the vest was potentially effective in decreasing off-task behaviour with 10% body weight, but not 5% body weight although there was an unusually high level of off-task behaviour noted in the second unweighted vest condition potentially associated with a change in the home environment. For David, there were a number of circumstances that were noted that may have affected the behaviours observed including an illness that may have decreased activity level. These potential confounds all impacted behaviour in a way opposite to the hypothesized behavioural effects of the vest, therefore there are suggestions that the vest may be effective for him if the outliers are removed. However, based on the available data, we cannot confidently conclude that the weighted vest was effective in decreasing off-task behaviour for David.

Overall, off-task behaviours were moderate (30% of intervals) to high (100% of intervals) across participants. There was considerable variability in off-task behaviour, within and between phases, for many participants. The weighted vest appeared to decrease variability for only one participant, Evan, during one phase. For Adam, off-task behaviour was more variable during weighted phases than unweighted phases.

Off-task behaviours were coded for the six participants for whom the weighted vest appeared effective or potentially effective, to help determine for what specific behaviours the weighted vest may be effective. Based on visual analysis and PND statistics, the data suggests that weighted vests were effective in decreasing visual attention to distractions (“looking away”) for three children (Adam, Connor, Evan), and effective in decreasing visual attention to distractions with 10% body weight, but not 5%

body weight, for two children (Ian, Jack). The data suggests that weighted vests were not effective in decreasing motoric (physical) stereotyped behaviours in any child for whom this was measured (Adam, Ian, Jack), but was effective in decreasing verbal stereotyped behaviour (delayed echolalia) in the one participant for whom this was measured (Connor). Tables 10-15 summarize the coded off-task behaviours for each participant for whom the weighted vests appeared to have an effect of decreasing off-task behaviour. Tables 10-15 also include the percentage of intervals during which each participant was off-task during each condition for comparison. Figure 15 displays stereotyped behaviours for Jack, observed independent from off-task behaviour.

Figure 5. Off-task behaviour for Adam.



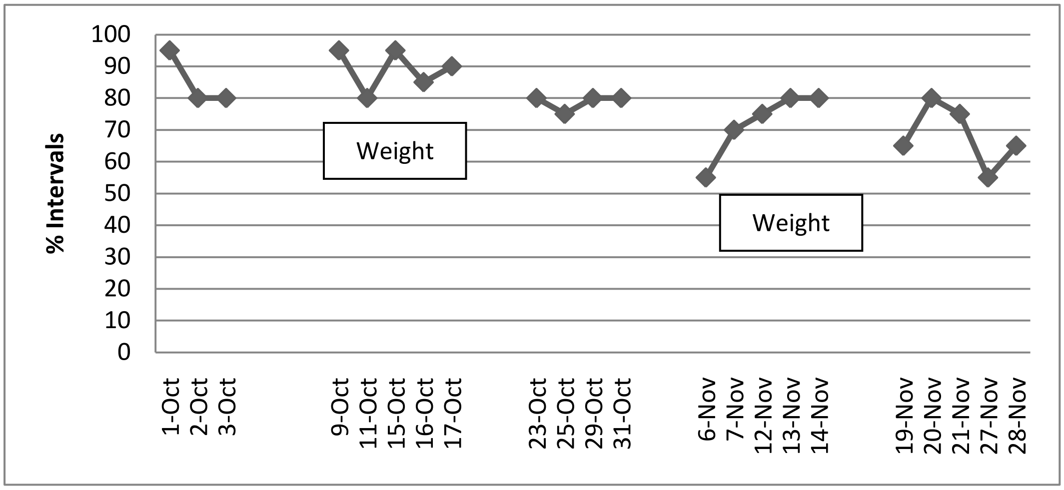
PND = [(3+4) / (5+5)] x 100 = 70%

Five percent body weight was used in both weighted phases. The lowest point in each B phase was used to calculate PND because a decrease in off-task behaviour was desired with the treatment.

Table 10. Adam coding of off-task behaviours

Behaviour	% Intervals Baseline (average)	% Intervals No Weight (average)	% Intervals Weight (average)	PND
Off-Task	67	72	50	70%
Stereotype: flicking fidget belt	20	27	20	40%
Looking away	62	69	48	70%

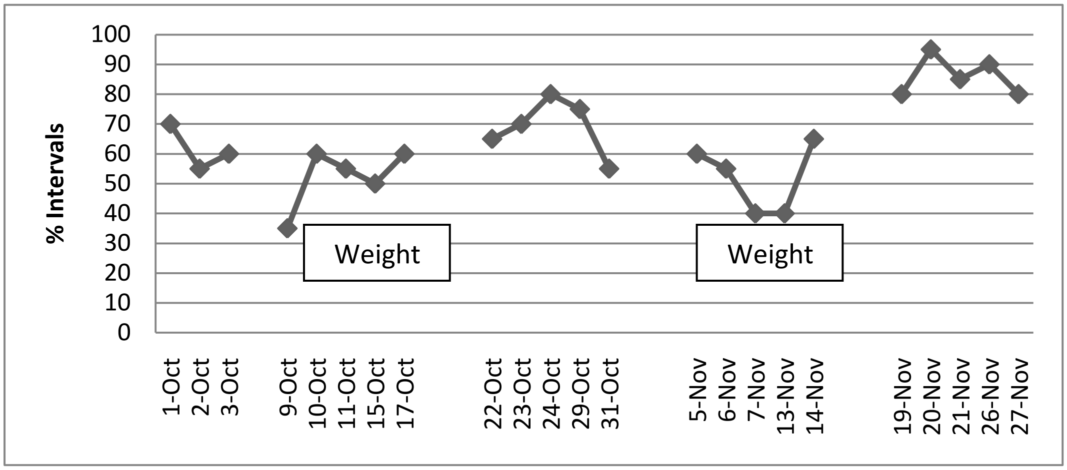
Figure 6. Off-task behaviour for Bobby.



PND = [(0 + 0) / (5 + 5)] x 100 = 0%

Data is expressed as the percentage of 15-second intervals during which Bobby was off-task within a 5-minute structured, table-top activity each day. Five percent body weight was used in both weighted phases. The lowest point in each B phase was used to calculate PND because a decrease in off-task behaviour was desired with the treatment.

Figure 7. Off-task behaviour for Connor.



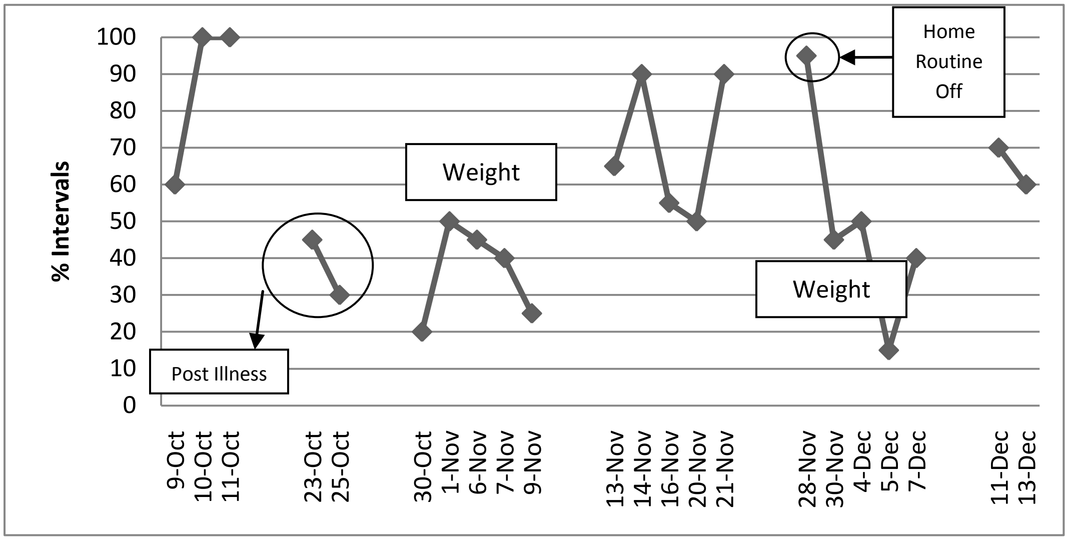
PND = [(2+5) / (5+5)] x 100 = 70%

Data is expressed as the percentage of 15-second intervals during which Connor was off-task within a 5-minute structured, table-top activity each day. Five percent body weight was used in both weighted phases. The lowest point in each B phase was used to calculate PND because a decrease in off-task behaviour was desired with the treatment.

Table 11. Connor coding of off-task behaviours

Behaviour	**% Intervals Baseline (average)**	**% Intervals No Weight (average)**	**% Intervals Weight (average)**	**PND**
Off-Task	62	78	52	70%
Looking away	50	63	39	60%
Stereotype: Delayed Echolalia	27	35	17	60%

Figure 8. Off-task behaviour for David.



PND = [(2+3) / (5+5)] x 100 = 50%

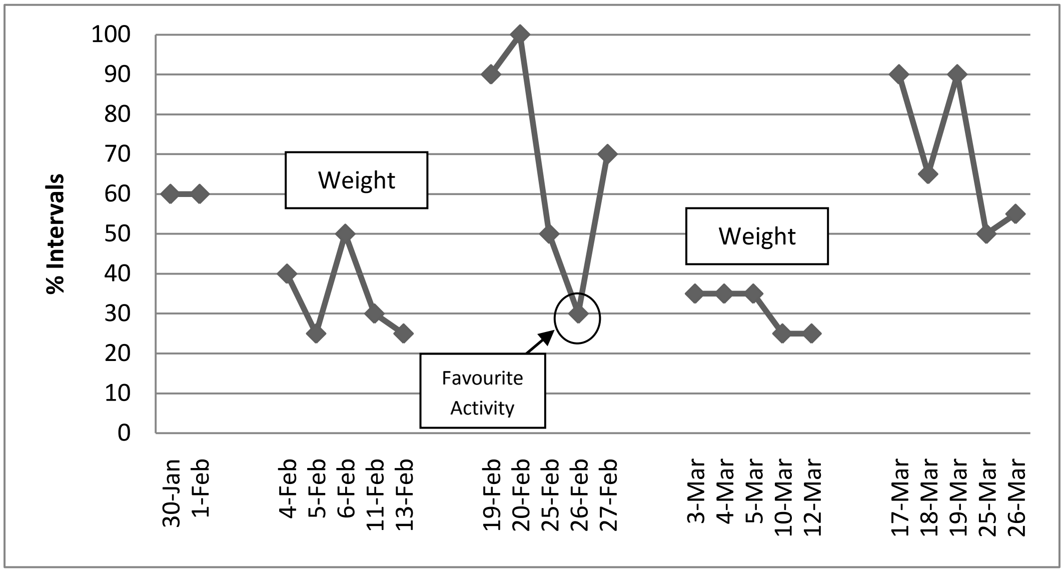
*Oct 23 & 25, Dec 11 & 13 form combined baseline for Oct 30-Nov 9 for PND calculation

Data is expressed as the percentage of 15-second intervals during which David was off-task within a 5-minute structured, table-top activity each day. Five percent body weight was used in both weighted phases. The transition from phase B_1 to phase C_1 accidently occurred after one week of data collection. Therefore, one extra week of data collection was added at the end (2 data points). The lowest point in each B phase was used to calculate PND because a decrease in off-task behaviour was desired with the treatment.

Table 12. David coding of off-task behaviours

Behaviour	% Intervals Baseline (average)	% Intervals No Weight (average)	% Intervals Weight (average)	PND
Off-Task	87	58	43	50%
Looking away	70	54	40	30%
Playing with materials	10	2	13	0%

Figure 9. Off-task behaviour for Evan.



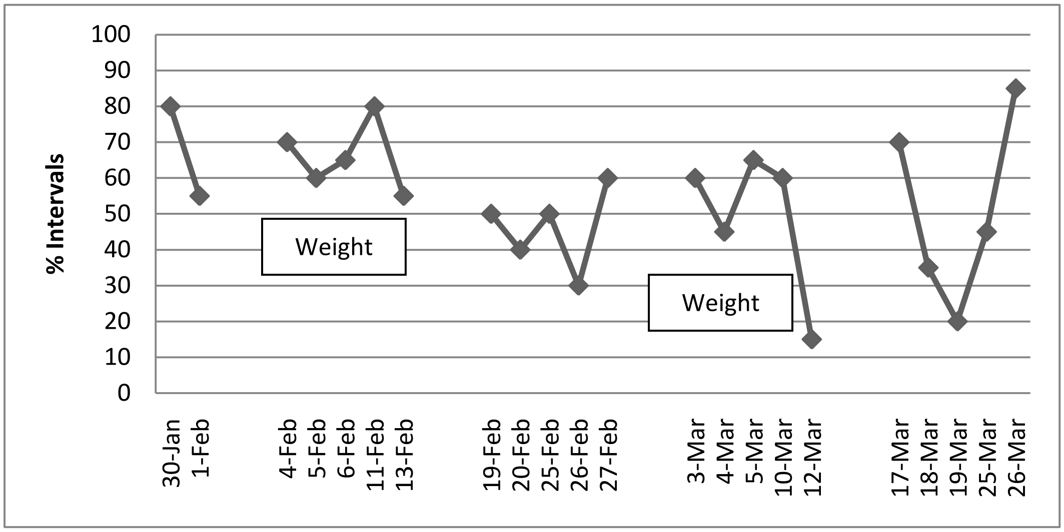
PND all data= [(2+5) / (5+5)] x 100 = 70%

Data is expressed as the percentage of 15-second intervals during which Evan was off-task within a 5-minute structured, table-top activity each day. Five percent body weight was used in both weighted phases. The lowest point in each B phase was used to calculate PND because a decrease in off-task behaviour was desired with the treatment.

Table 13. Evan coding of off-task behaviours

Behaviour	**% Intervals Baseline (average)**	**% Intervals No Weight (average)**	**% Intervals Weight (average)**	**PND**
Off-Task	60	69	33	70%
Looking away	50	68	32	70%
Prompt required to engage	10	9	7	0%

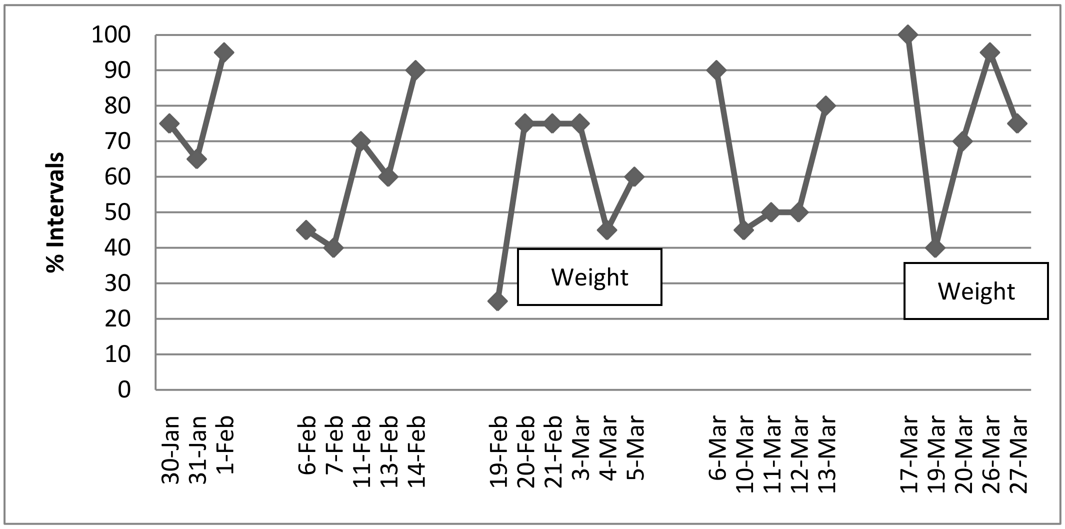
Figure 10. Off-task behaviour for Fabian.



PND = [(0+1) / (5+5)] x 100 = 10%

Data is expressed as the percentage of 15-second intervals during which Fabian was off-task within a 5-minute structured, table-top activity each day. Five percent body weight was used in both weighted phases. The lowest point in each B phase was used to calculate PND because a decrease in off-task behaviour was desired with the treatment.

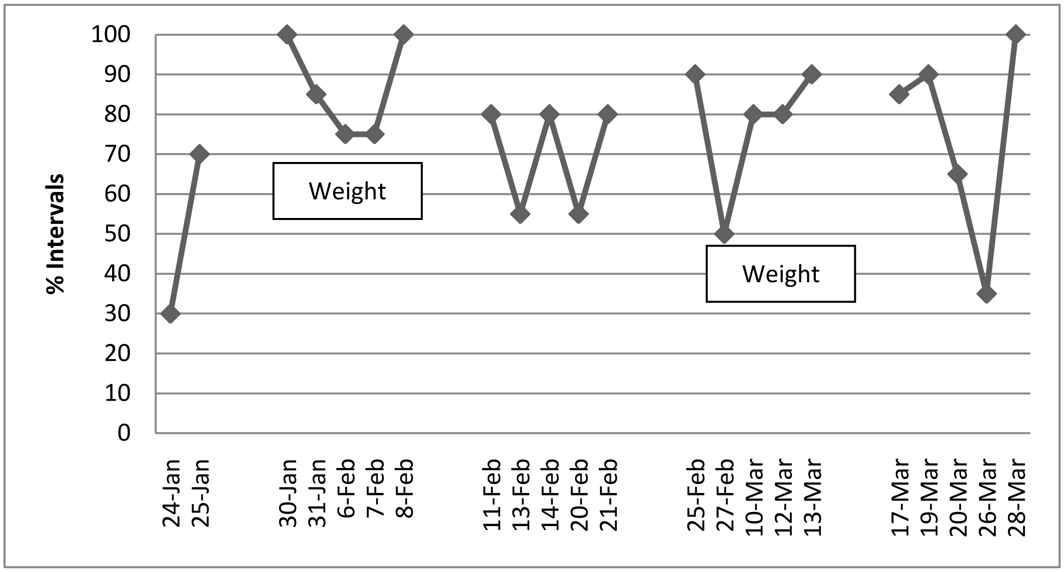
Figure 11. Off-task behaviour for Grace.



PND = [(1+1) / (6+5)] x 100 = 18%

Data is expressed as the percentage of 15-second intervals during which Grace was off-task within a 5-minute structured, table-top activity each day. Five percent body weight was used in both weighted phases. The lowest point in each B phase was used to calculate PND because a decrease in off-task behaviour was desired with the treatment.

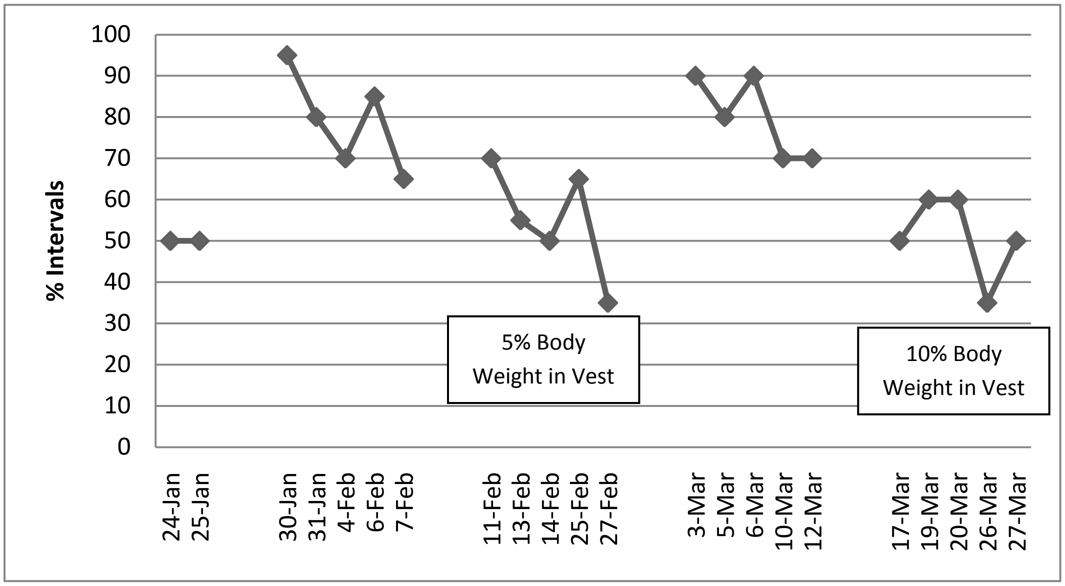
Figure 12. Off-task behaviour for Hailey.



PND = [(0+0) / (5+5)] x 100 = 0%

Data is expressed as the percentage of 15-second intervals during which Hailey was off-task within a 5-minute structured, table-top activity each day. Five percent body weight was used in both weighted phases. The lowest point in each B phase was used to calculate PND because a decrease in off-task behaviour was desired with the treatment.

Figure 13. Off-task behaviour for Ian.



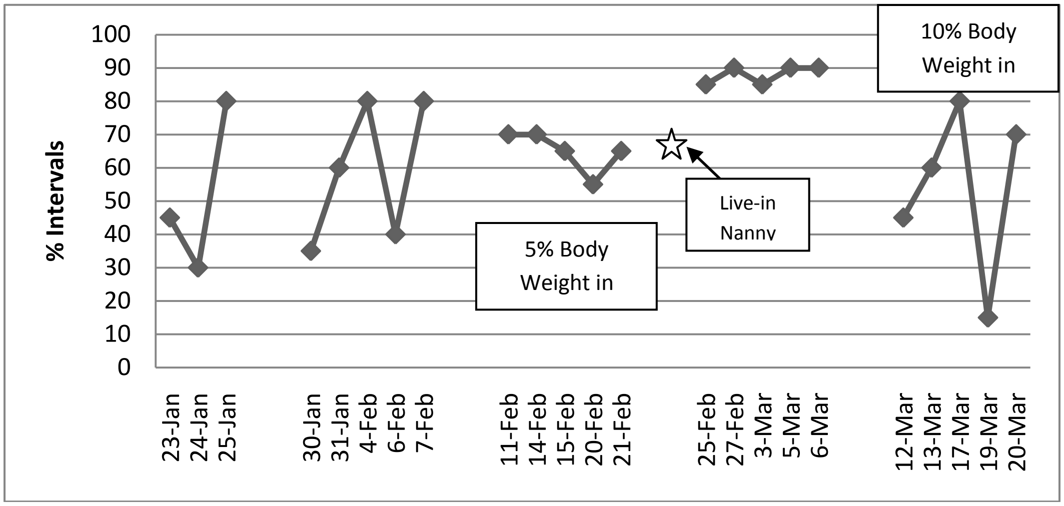
PND = [(3+5) / (5+5)] x 100 = 80% (60% for 5% weight; 100% for 10% weight)

Data is expressed as the percentage of 15-second intervals during which Ian was off-task within a 5-minute structured, table-top activity each day. Five percent body weight was used in phase C_1; 10% body weight was used in phase C_2. The lowest point in each B phase was used to calculate PND because a decrease in off-task behaviour was desired with the treatment.

Table 14. Ian coding of off-task behaviours

Behaviour	**% Intervals Baseline (average)**	**% Intervals No Weight (average)**	**% Intervals Weight (average)**	**PND**
Off-Task	50	80	53	80%
Looking away	28	64	43	50%
Stereotype: hand/finger mannerisms; flicking objects	10	26	21	0%

Figure 14. Off-task behaviour for Jack.



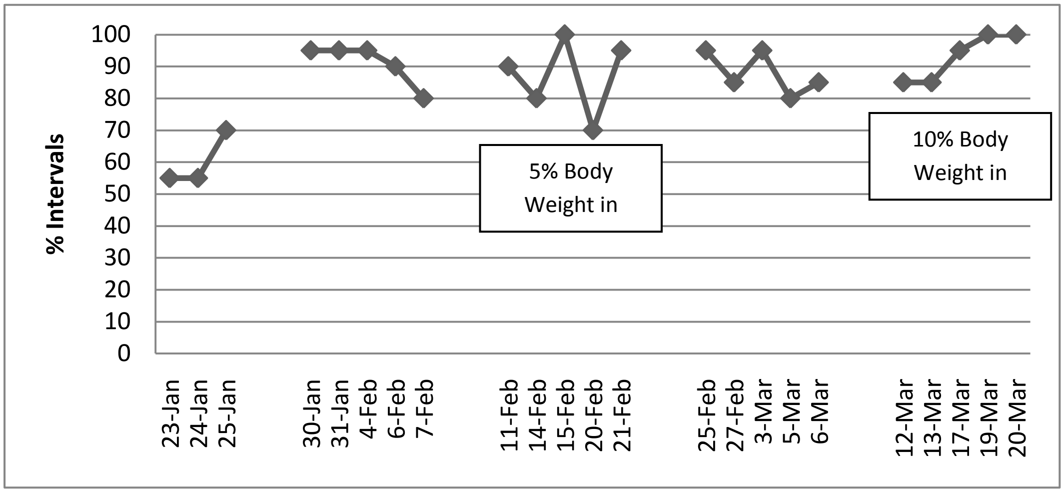
PND = [(0+5) / (5+5)] x 100 = 50% (0% for 5% weight; 100% for 10% weight)

Data is expressed as the percentage of 15-second intervals during which Jack was off-task within a 5-minute structured, table-top activity each day. Five percent body weight was used in phase C_1; 10% body weight was used in phase C_2. The lowest point in each B phase was used to calculate PND because a decrease in off-task behaviour was desired with the treatment.

Table 15. Jack coding of off-task behaviours

Behaviour	**% Intervals Baseline (average)**	**% Intervals No Weight (average)**	**% Intervals Weight (average)**	**PND**
Off-Task	52	74	60	50%
Looking away	52	62	45	40%
Stereotype: rocking, hand flapping	52	43	38	20%

Figure 15. Stereotyped behaviour for Jack.



PND = [(1+0) / (5+5)] x 100 = 10%

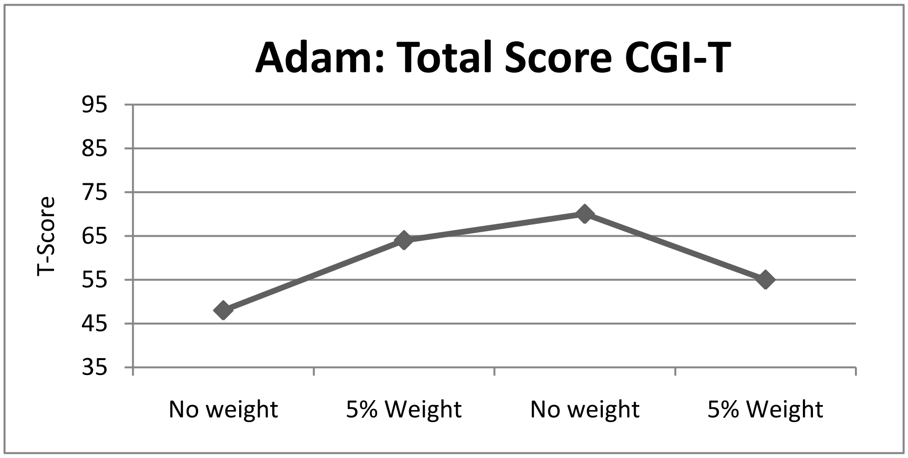
Data is expressed as the percentage of 15-second intervals during which Jack was engaged in stereotyped behaviour within a 5-minute structured, table-top activity each day. This includes stereotyped behaviours while Jack was both on and off-task. Five percent body weight was used in phase C_1; 10% body weight was used in phase C_2. The lowest point in each B phase was used to calculate PND because a decrease in stereotyped behaviour was desired with the treatment.

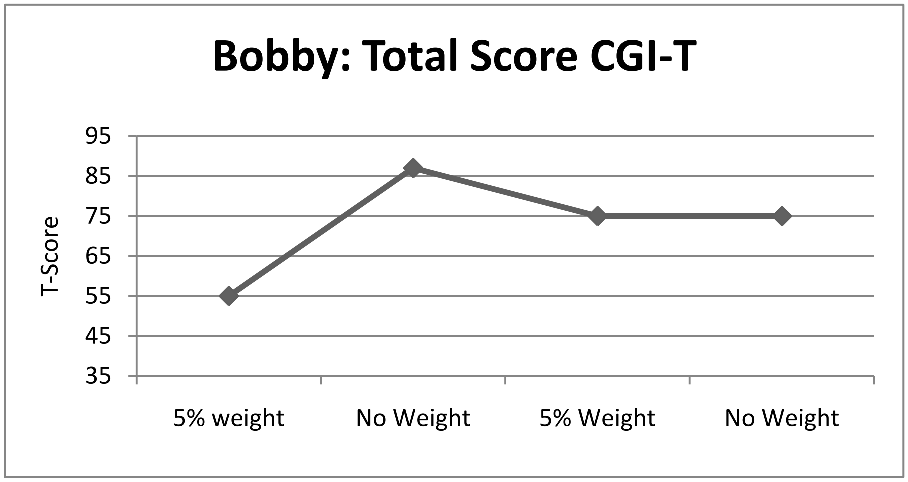
Teacher Ratings of Behaviour

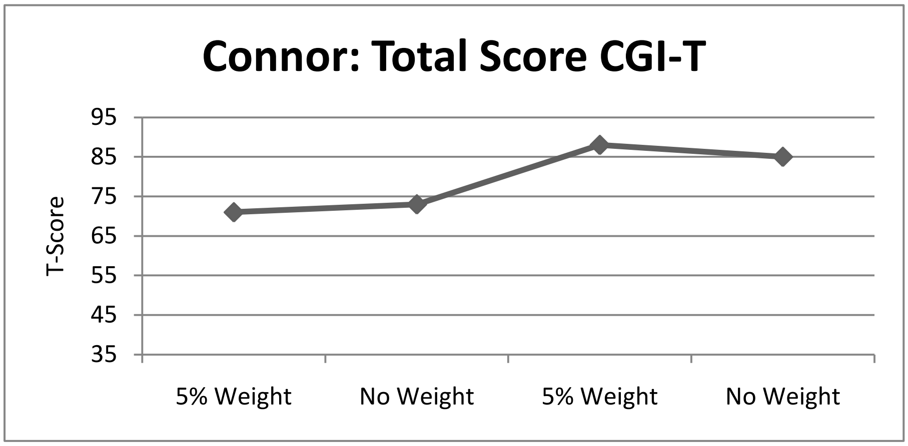
Teachers were blind to treatment condition and completed the CGI-T at the end of each 2-week phase, totaling four times. Figure 16 provides a visual representation of the CGI-T scores for each participant, which indicates the lack of clear alignment of CGI-T scores with changes from weighted to unweighted phases. Higher scores indicate more problematic behaviour. David is the only participant for whom the CGI-T results vary consistently with the phase, though differences are not marked. He is also the only child with a clinically significant positive change in CGI-T scores from both unweighted phases to the weighted phases. Seven children (Adam, Bobby, Evan, Fabian, Ian, Jack) showed a clinically significant positive change in CGI-T scores in one unweighted/weighted phase but not for both pairs of phases. Four children (Adam, Grace, Hailey, Jack) had a clinically significant negative change in CGI-T scores in one unweighted/weighted phase.

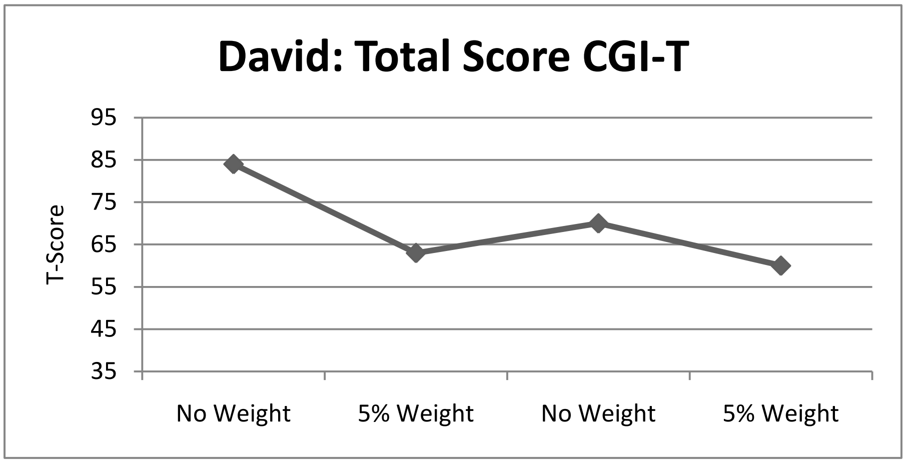
According to Conners (1997), scores of 55 or below should not raise concern. Although all participants had difficulty with attention to tasks, this was not reflected in the CGI-T scores for all participants. Evan scored within the typical range for each phase, and Fabian and Ian scored within the typical range for 3 of 4 phases, indicating few of the atypical behaviours measured on the CGI-T. Adam scored in the typical range for the first baseline phase, but not the other three phases. All other participants scored within the atypical range across all four phases.

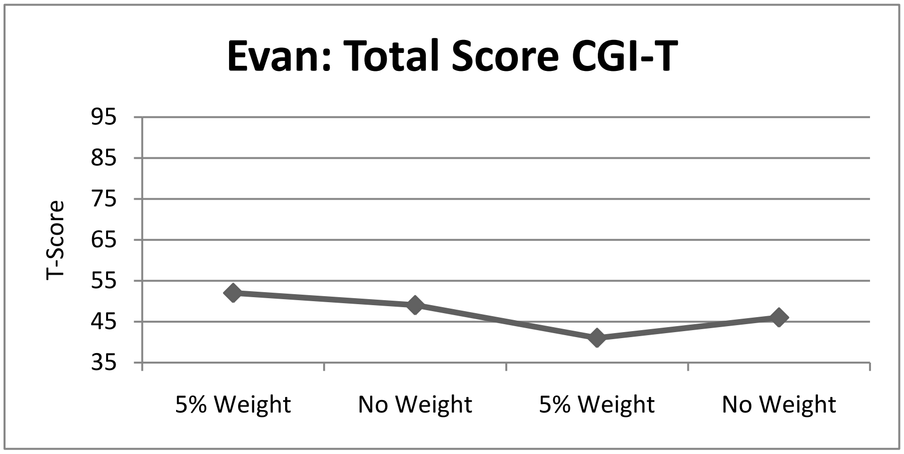
Figure 16. Conners' Global Index - Teacher Version (CGI-T) scores for each participant.

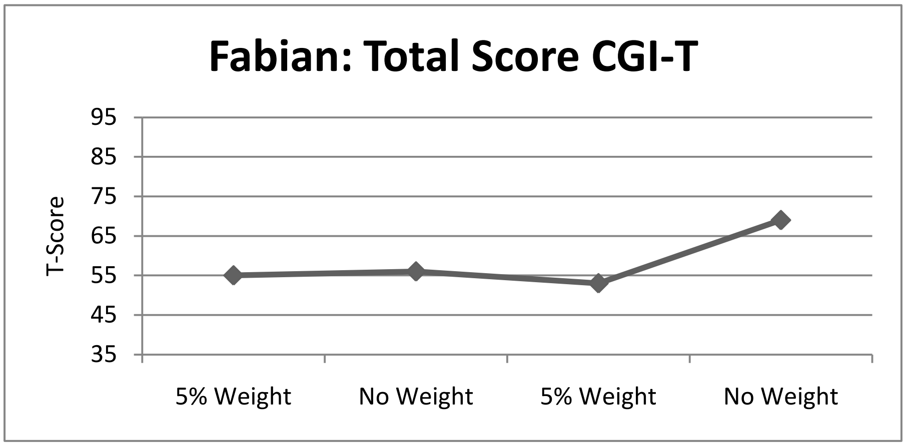


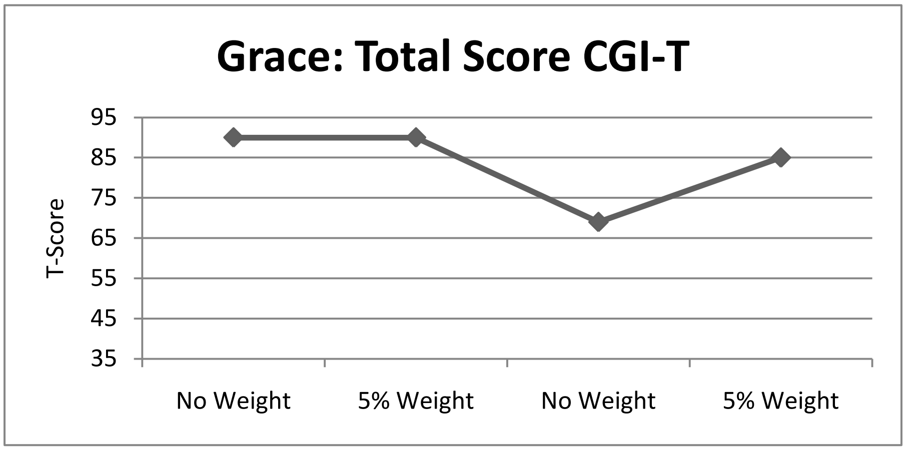


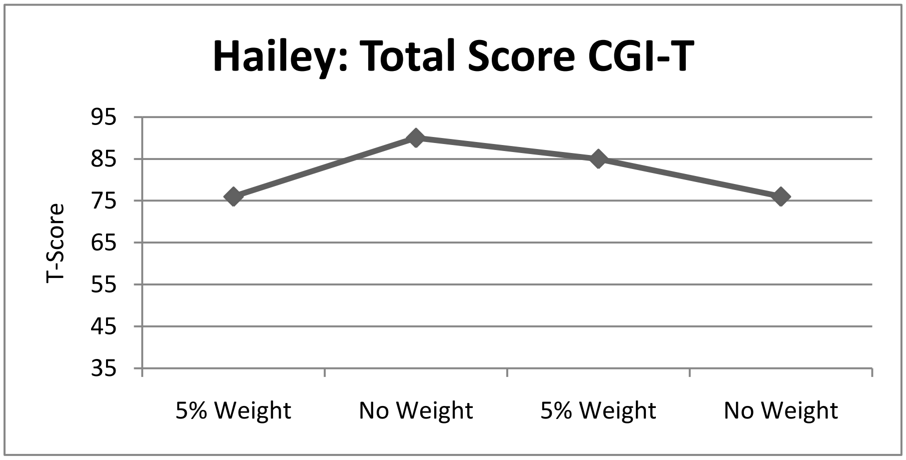

Connor: Total Score CGI-T
T-Score
95
85
75
65
55
45
35
5% Weight
No Weight
5% Weight
No Weight

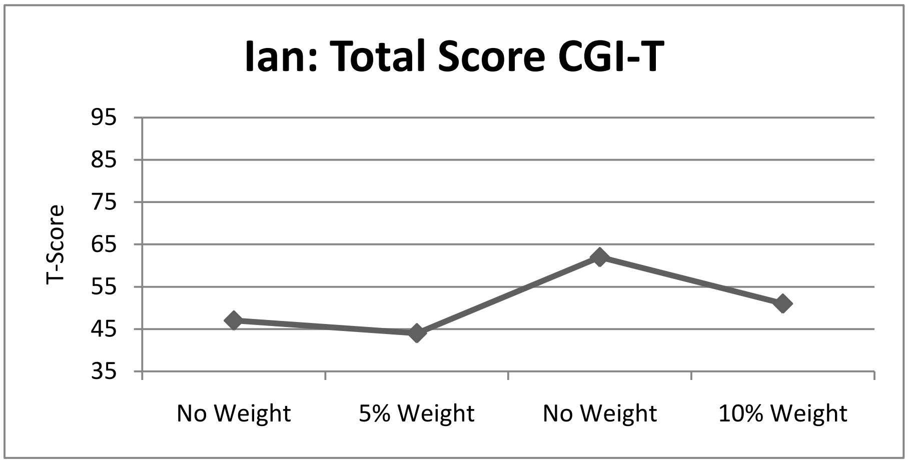

David: Total Score CGI-T
T-Score
95
85
75
65
55
45
35
No Weight
5% Weight
No Weight
5% Weight

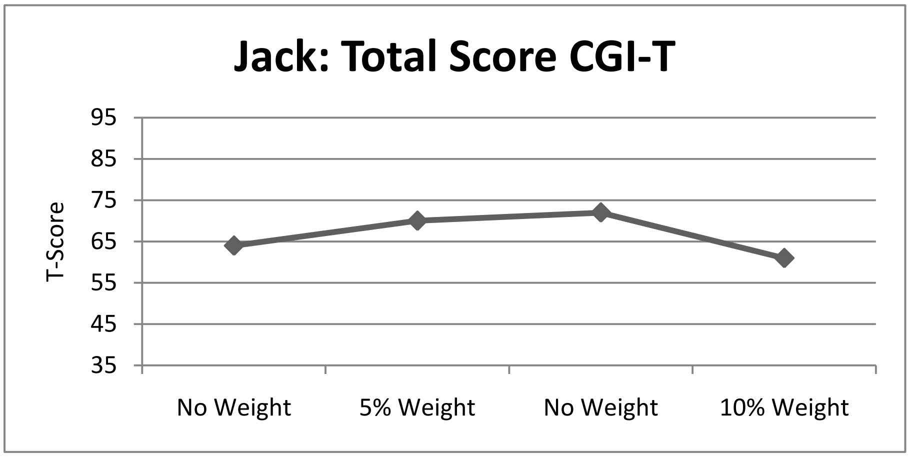

Evan: Total Score CGI-T
T-Score
95
85
75
65
55
45
35
5% Weight
No Weight
5% Weight
No Weight


Fabian: Total Score CGI-T
T-Score
95
85
75
65
55
45
35
5% Weight
No Weight
5% Weight
No Weight


Grace: Total Score CGI-T
T-Score
95
85
75
65
55
45
35
No Weight
5% Weight
No Weight
5% Weight


Hailey: Total Score CGI-T
T-Score
95
85
75
65
55
45
35
5% Weight
No Weight
5% Weight
No Weight





Higher T-scores (mean = 50, SD = 10) are associated with a greater frequency and/or number of problem behaviours. Conners' (1997) suggests that T-scores lower than 55 are not cause for concern, and T-scores higher than 65 indicate a clinically significant behavioural problem. Changes in T-scores of 5 or more points are viewed as significant treatment effects.

Table 16 provides a summary of the scores on the CGI-T compared with objective behavioural ratings of off-task behaviours. Overall, results from the CGI-T did not align with objective behavioural results of improvements in off-task behaviour in the 5 minutes of coded data collected five times per phase. It must be remembered that the children were wearing the vests (weighted and unweighted) 20 to 30 minutes per day even on days when video data were not being collected. Teacher impressions of behaviour included the days that were not video recorded.

For David, CGI-T score changes corresponded with his objective behavioural results, based on PND statistics, across phases. However, as discussed earlier, all of

David's data needs to be interpreted with caution due to potential confounding events. CGI-T scores corresponded with an improvement in off-task behaviour for one weighted/unweighted comparison for four children: Adam, Evan, Ian and Jack. However, CGI-T scores did not indicate a positive change for Adam, Evan and Ian during the first weighted/ unweighted comparison when visual analysis indicated an improvement in off-task behaviour. Visual analysis for Jack indicated no behavioural effect during the first weighted/unweighted comparison while CGI-T indicated a negative response to the weighted condition. CGI-T scores corresponded with no change in behaviour for one weighted/non-weighted comparison for Fabian and Grace – neither the CGI-T or visual analysis indicated an effect with the weighted condition. For the other comparisons, CGI-T scores indicated a positive effect for Fabian and a negative effect for Grace when visual analysis did not indicate any effect.

Table 16. Comparison of objective changes in off-task behaviour and changes on the Conners' Global Index-Teacher.

	Comparison of First Weighted to First Unweighted Phase			Comparison of Second Weighted to Second Unweighted Phase		
Child	Behavioural data*	CGI-T**	Agree?	Behavioural Data	CGI-T	Agree?
Adam	Positive effect	Negative change	No	Positive effect	Positive change	Yes
Bobby	No effect	Positive change	No	No effect	No change	Yes
Connor	Positive effect	No change	No	Positive effect	No change	No
David	Positive effect, but potential confounds	Positive change	Yes	Positive effect	Positive change	Yes
Evan	Positive effect	No change	No	Positive effect	Positive change	Yes
Fabian	No effect	No change	Yes	No effect	Positive change	No
Grace	No effect	No change	Yes	No effect	Negative change	No
Hailey	No effect	Positive change	No	No effect	Negative change	No
Ian	Positive effect with weight back to baseline	No change	No	Positive effect with weight back to baseline	Positive change	Yes
Jack	No effect	Negative change	No	Positive effect	Positive change	Yes

*In the behavioural columns, “positive effect” means a decrease in off-task behaviour with the weighted vest and “negative effect” means an increase in off-task behaviour with the weighted vest. These effects are based on visual analysis and PND statistics.

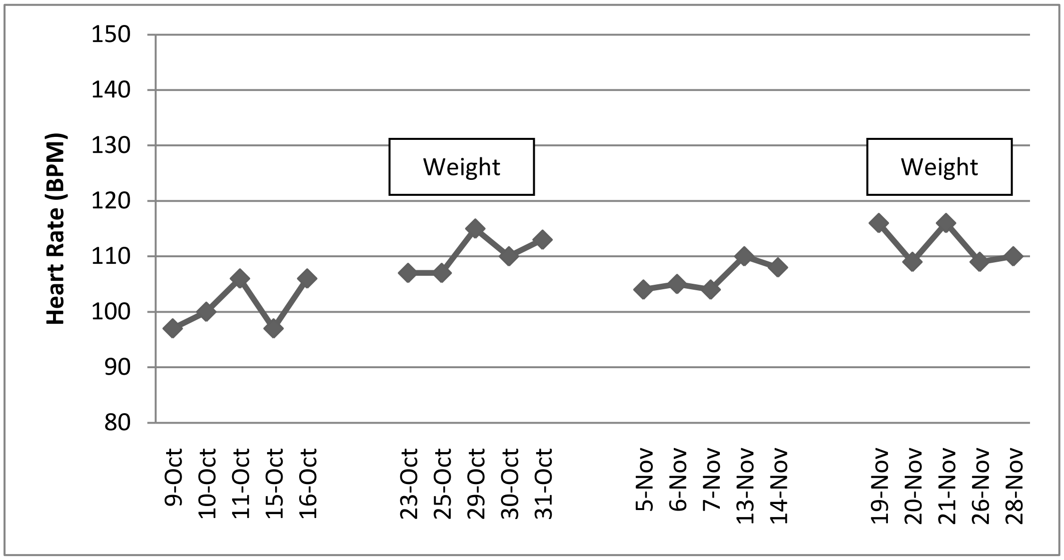
**For the CGI-T a “positive change” means a decreased T-score of at least 5-points and a “negative change” means an increased T-score of at least 5 points.

Physiological Data: Heart rate

Heart rate was not monitored during phase A, therefore graphs for physiological data only have the four treatment-withdrawal (BCBC/CBCB) phases. Heart rate was measured in 7 of 10 participants. Two children physically resisted the monitor by pulling it off or pushing it away when it was presented and the other verbally refused to wear the heart rate monitor. PND statistics of heart rate data suggests that the weighted vests had a questionable (Scruggs & Mastropierie, 1998) treatment effect of decreasing heart rate in two children (David, Evan). However, visual analysis does not support an effect for these two children. Visual analysis and PND statistics indicate that the weighted vest was associated with increasing heart rate in one child (Adam), but based on visual analysis this effect appears small. Visual analysis and PND data indicates that the weighted vests did not have an effect on heart rate in the other four participants. Graphs are presented in Figures 17-23. Descriptive statistics of heart rate data are presented in Tables 17-23.

Scatter plots with trend lines were used to indicate the potential direction of heart rate change over time. A scatter plot was done for each participant for each treatment (weighted) data collection day, totaling 69 graphs (Adam=10; Bobby=10; David=9; Evan=9; Grace=11; Hailey=10; Ian=10). Of the 69 scatter plots created, 53 indicated a flat trend in heart rate over time (R^2 = 0.0001-0.9213), 4 indicated a slight upwards trend in heart rate (R^2 = 0.1075-0.3845), 9 indicated a slight downwards trend (R^2 = 0.0305-0.3738), and 3 indicated a more obvious downwards trend (R^2 = 0.0802-0.5061). Overall, the strength of the direction of the trend lines was weak. Therefore, scatter plots did not indicate that heart rate would have shown a meaningful change if it had been collected over a longer period of time.

Figure 17. Adam's mean heart rate while wearing the vest.



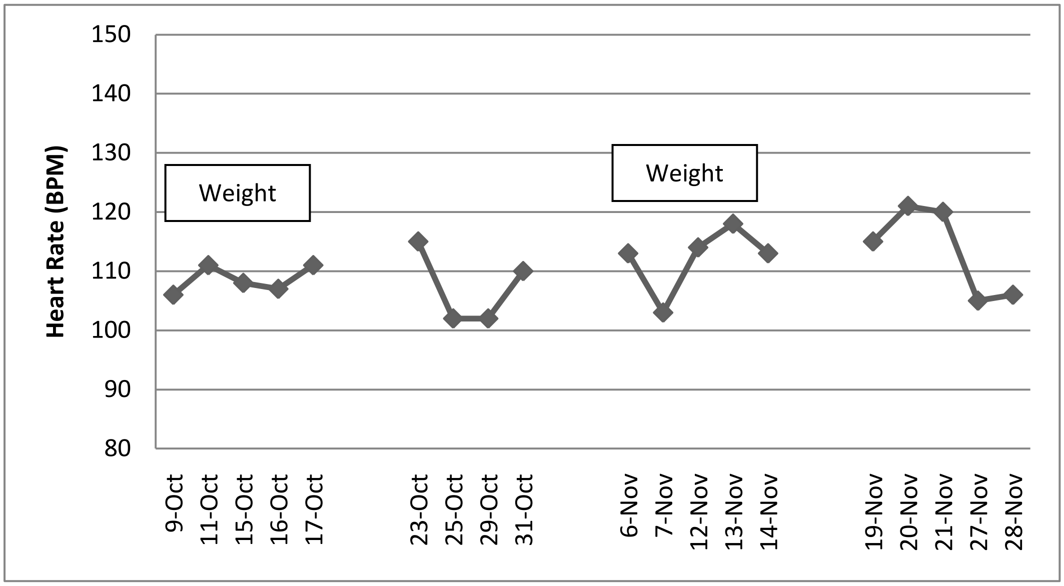
PND decrease heart rate = [(0+0) / (5+5)] x 100 = 0%
PND increase heart rate = [(5+2) / (5+5)] x 100 = 70%

Unlabeled phases represent the unweighted baseline phases (B). Treatment phases (C) are labeled as "Weight". There was 5% body weight in the vest. The lowest point in each B phase was initially used to calculate PND because a decrease in heart rate was anticipated with the treatment. However, because Adam demonstrated a noticeable increase in heart rate, we also calculated PND based on the highest point in each B phase.

Table 17. Adam's heart rate data

Phase	Pooled Range	Pooled Mean	Pooled SD
No weight	78-116	102.21	5.608
Weight	95-134	110.45	6.695
No weight	91-120	105.97	5.288
Weight	92-130	111.98	0.665

Figure 18. Bobby's mean heart rate while wearing the vest.



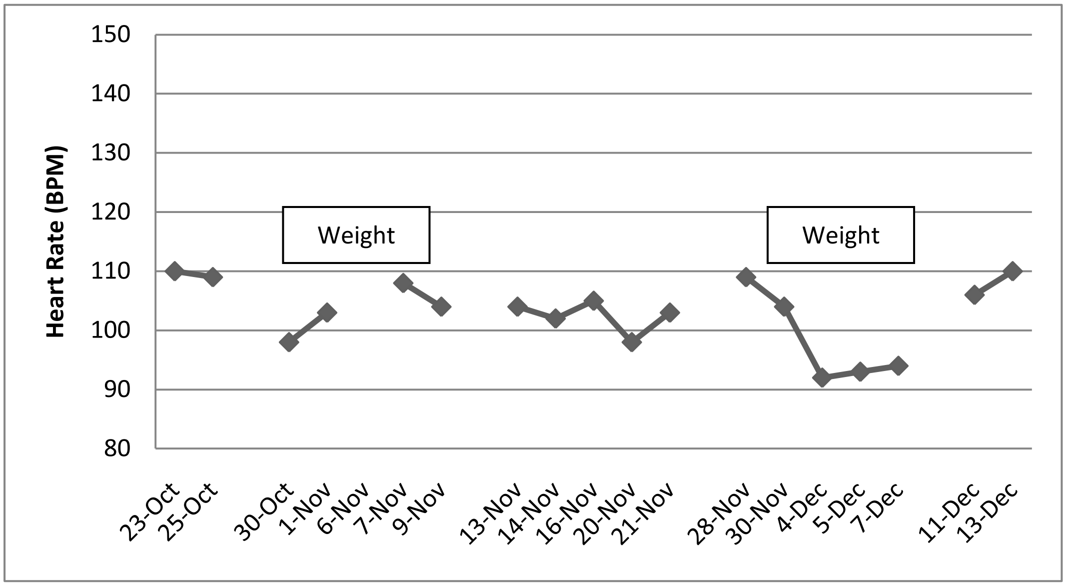
PND = [(0+1) / (5+5)] x 100 = 10%

Unlabeled phases represent the unweighted baseline phases (B). Treatment phases (C) are labeled as "Weight". There was 5% body weight in the vest. The lowest point in each B phase was used to calculate PND because a decrease in heart rate was anticipated with the treatment.

Table 18. Bobby's heart rate data

Phase	Pooled Range	Pooled Mean	Pooled SD
Weight	87-136	108.57	8.441
No weight	87-132	108.49	8.374
Weight	97-137	112.66	7.268
No weight	94-155	113.50	9.294

Figure 19. David's mean heart rate while wearing the vest.



PND = [(3+3) / (4+5)] x 100 = 67%

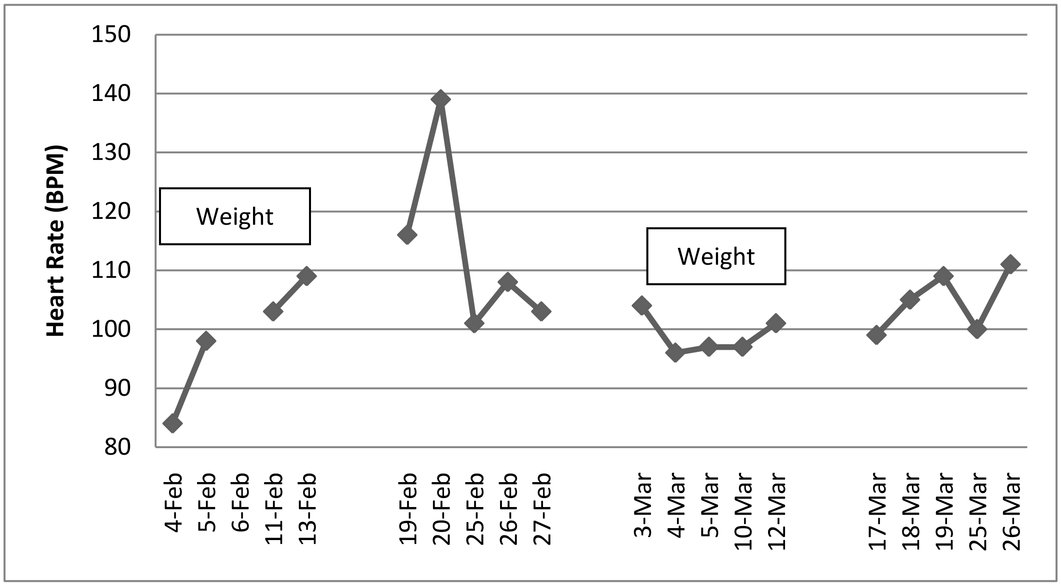
*Oct 23 & 25, Dec 11 & 13 form combined baseline for Oct 30-Nov 9 for PND calculation

Unlabeled phases represent the unweighted baseline phases (B). Treatment phases (C) are labeled as "Weight". There was 5% body weight in the vest. The transition from phase B_1 to phase C_1 accidently occurred after one week of data collection. Therefore, one extra week of data collection was added at the end (2 data points). The lowest point in each B phase was used to calculate PND because a decrease in heart rate was anticipated with the treatment.

Table 19. David's heart rate data

Phase	Pooled Range	Pooled Mean	Pooled SD
No weight	96-126	109.50	5.191
Weight	86-125	103.62	7.204
No weight	81-140	102.24	8.367
Weight	77-123	98.79	9.541
No weight	86-124	109.36	7.872

Figure 20. Evan's mean heart rate while wearing the vest.



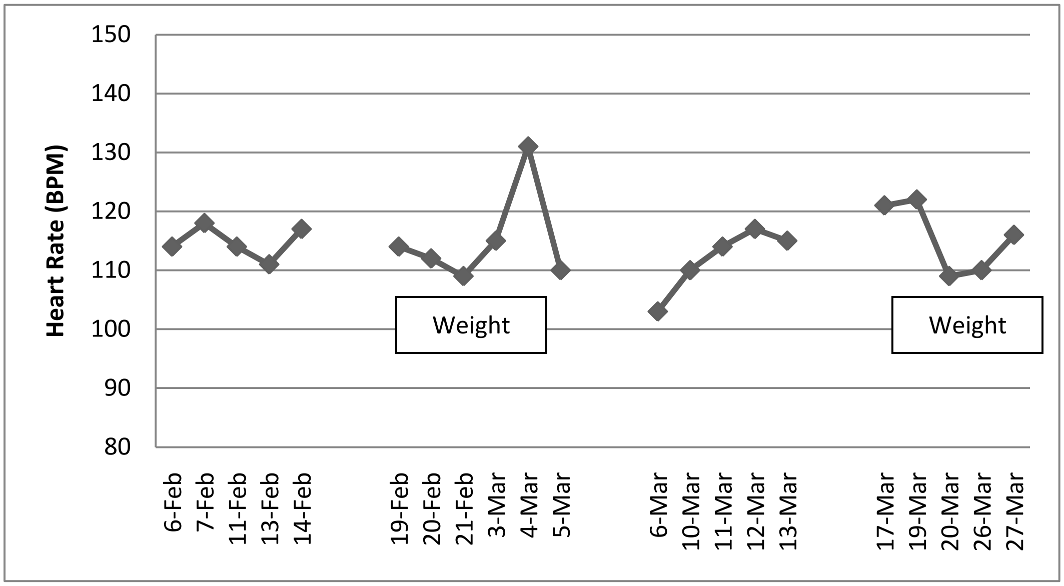
PND = [(2+3) / (4+5)] x 100 = 56%

Unlabeled phases represent the unweighted baseline phases (B). Treatment phases (C) are labeled as "Weight". There was 5% body weight in the vest. The lowest point in each B phase was used to calculate PND because a decrease in heart rate was anticipated with the treatment.

Table 20. Evan's heart rate data

Phase	Pooled Range	Pooled Mean	Pooled SD
Weight	76-124	99.33	10.825
No weight	90-157	116.14	15.257
Weight	80-121	98.44	6.678
No weight	88-129	104.14	7.475

Figure 21. Grace's mean heart rate while wearing the vest.



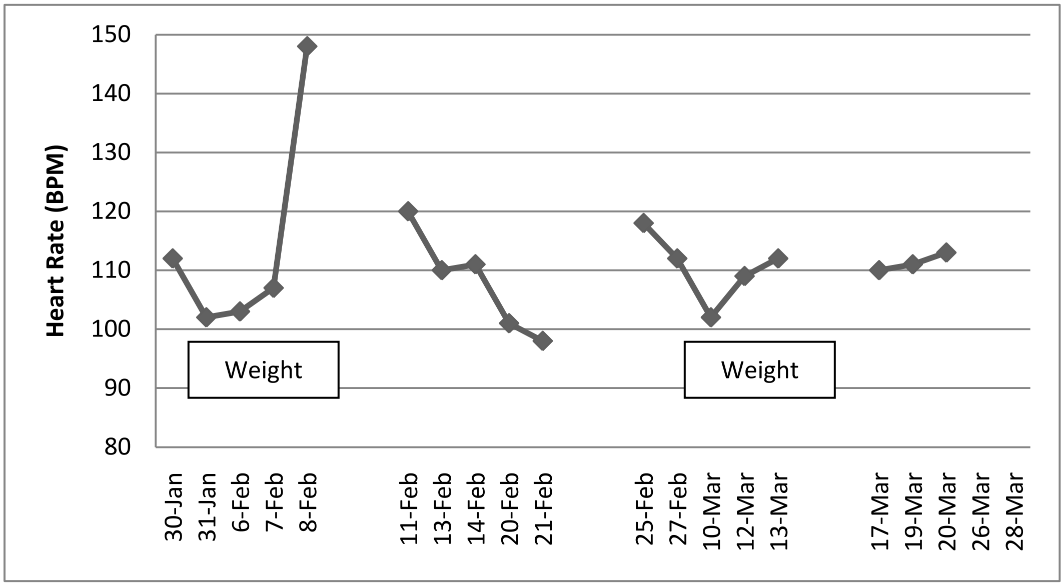
PND = [(2+0) / (6+5)] x 100 = 18%

Unlabeled phases represent the unweighted baseline phases (B). Treatment phases (C) are labeled as "Weight". There was 5% body weight in the vest. The lowest point in each B phase was used to calculate PND because a decrease in heart rate was anticipated with the treatment.

Table 21. Grace's heart rate data

Phase	Pooled Range	Pooled Mean	Pooled SD
No weight	97-168	113.99	7.360
Weight	97-169	114.91	11.488
No weight	93-158	111.84	9.120
Weight	91-151	115.84	10.040

Figure 22. Hailey's mean heart rate while wearing the vest.



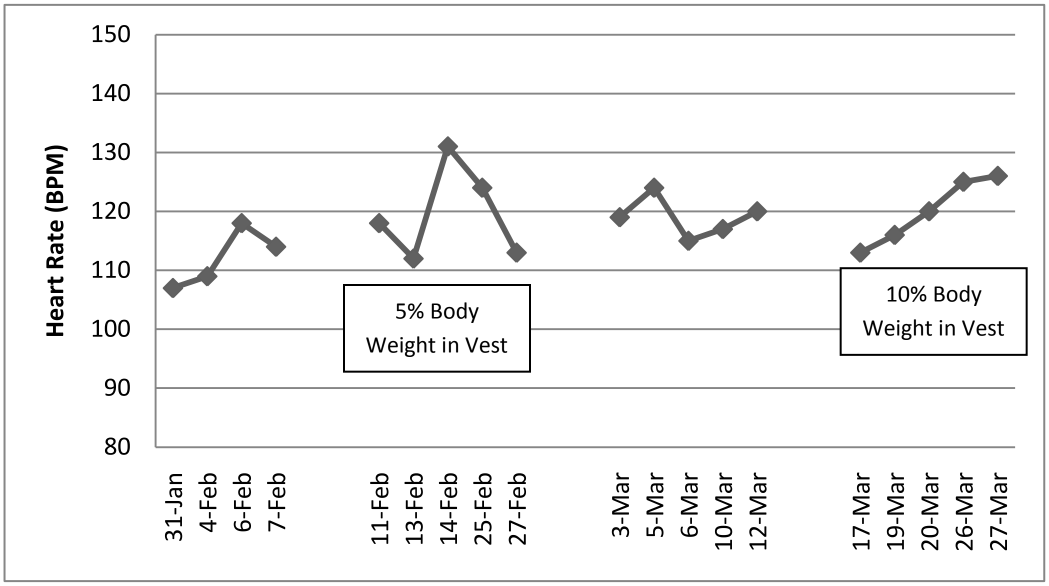
PND = [(0+2) / (5+5)] x 100 = 20%

Unlabeled phases represent the unweighted baseline phases (B). Treatment phases (C) are labeled as "Weight". There was 5% body weight in the vest. The lowest point in each B phase was used to calculate PND because a decrease in heart rate was anticipated with the treatment.

Table 22. Hailey's heart rate data

Phase	Pooled Range	Pooled Mean	Pooled SD
Weight	87-186	111.94	18.874
No weight	85-136	105.07	10.872
Weight	89-169	111.61	13.886
No weight	92-151	110.90	11.330

Figure 23. Ian's mean heart rate while wearing the vest.



PND = [(0+1) / (5+5)] x 100 = 10%

Unlabeled phases represent the unweighted baseline phases (B). Treatment phases (C) are labeled as "Weight". Five percent body weight was used in phase C_1; 10% body weight was used in phase C_2. The lowest point in each B phase was used to calculate PND because a decrease in heart rate was anticipated with the treatment.

Table 23. Ian's heart rate data

Phase	Pooled Range	Pooled Mean	Pooled SD
No weight	75-134	114.15	7.801
Weight	98-169	118.95	11.817
No weight	71-155	118.49	8.166
Weight	94-144	120.03	8.260

Teacher and Aide Feedback Regarding Weighted Vests

Prior to implementation of the vests, all teachers and aides involved in the study were asked about their knowledge of, and experience with, weighted vests. All five of the teachers had heard about weighted vests prior to the study, and three of the five had experience with weighted vest usage for 2, 3 and 10 students. All three of the teachers with previous experience reported that they thought that weighted vests had positive effects for approximately half of the children with whom they were used. Reported benefits included improved attention and helping a child to stay calm. Eight of the nine educational aides had heard of weighted vests prior to the study, and five of these aides had experience with weighted vests, each with 3 to 4 different children. All five of the aides with previous experience reported that the weighted vests had positive effects for 50 to 100% of the children with whom they were used. Reported benefits included helping a child stay calm, sit longer, be quieter, and decrease spinning.

Following completion of video data collection, aides were asked if they thought the weighted vest was effective for each participant, and, if so, for what behaviours it was effective. They were also asked if they would like to continue using the weighted vest with each participant. Six of the nine aides viewed the vests as effective with the remainder viewing them as sometimes effective. Three of the aides were not sure they wanted to continue with use of the vest while the other six would continue.

Teachers were blinded to treatment condition; therefore, teachers could not provide meaningful subjective opinions about treatment effects based on their observations during the study. However, when asked if they would like to continue using the weighted vest, teachers reported that they would like to continue using weighted vests with all participants. Table 24 summarizes teacher and aide responses following data collection.

When the vests were picked up approximately one month following the end of data collection, each teacher and/or aide was asked if the vest had been used since the end of data collection, which provided a measure of habilitative validity. The weighted vests were only used with three children during the month following data collection.

Table 24. Teacher and aide feedback regarding weighted vests. Aides provided subjective feedback of perceived effects (aide was not blinded to treatment condition)

Child	Aide: Was vest effective? If yes, for what?	Aide: Do you want to continue use of vest?	Teacher: Do you want to continue use of vest?	Was it used at follow-up? If yes, for what?
Adam	Sometimes: focus	Maybe	Yes	No: No reason given
Bobby	Sometimes: Calm, focus	Maybe	Yes	No: No reason given
Connor	Yes: Calm, focus	Yes	Yes	Yes: Seated activities, transitions between classrooms
David	Yes: Sit with fewer prompts	Yes	Yes	No: No reason given
Evan	Yes: Focus	Yes	Yes	No: Awaiting results
Fabian*	Sometimes: Focus	Maybe	Yes	No: Awaiting results
Grace*	Sometimes: Focus	Yes	Yes	No: Awaiting results
Hailey	Yes: Able to wait and listen	Yes	Yes	Yes: Seated activities
Ian	Yes: focus, increased vocalizations	Yes	Yes	Yes: Seated activities
Jack	Yes: Sit better (5% weight)	Yes: with 5% weight	Yes	No: Trialing pressure vest

*same aide

Summary of Results

Our first hypothesis, that touch-pressure sensory input applied through a weighted vest would result in decreased off-task behaviour, increased sitting time, and decreased stereotyped behaviours in the participants, was partially supported with objective data. Based on objective analysis of video data, the weighted vest appeared effective in decreasing off-task behaviour in three of the participants (Adam, Connor, Evan), and potentially effective in decreasing off-task behaviours in two participants (David, Jack), although potential confounds limit our ability to confidently state positive treatment effects. For one participant (Ian), the unweighted vest may have had a negative influence, which was negated by the weight, but no more so than no intervention. There were no effects of weighted vests on duration of sitting for the three children for whom this was measured or for motoric stereotyped behaviours for the five children for whom this was measured. The weighted vest appeared effective in decreasing verbal stereotyped behaviours in the one participant (Connor) for whom this behaviour was measured. Although we predicted that teachers would perceive behavioural benefits of weighted vests, objective teacher ratings of behaviour did not indicate consistent positive effects of the weighted vest on behaviour in 9 of 10 participants.

Our second hypothesis, that heart rate would decrease with weighted vests, was not supported. The weighted vest was not effective in decreasing heart rate in any participants, although it did appear to increase heart rate in one participant (Adam).

The hypothesis that teachers and educational assistants would think that weighted vests were acceptable tools for use to enable children with autism to function more productively in the classroom was supported. Subjectively, all aides reported that the weighed vests were effective in improving behaviours at least sometimes in all participants and that they would like to continue using weighted vests. Although teachers could not provide meaningful subjective impressions of effects because they were blinded, teachers reported that they would like to continue to use the weighted vest with each participant.

When all sources of data are looked at together, no participant showed positive effects across all indicators, but many participants (Adam, Connor, David, Evan, Ian, and Jack) showed mixed results, with positive effects across multiple indicators. However, David's and Jack's results may be confounded by external variables making a conclusive statement of effectiveness difficult, and Ian's video data appears to indicate a wash-out effect due to an initial increase in negative behaviours with the heart rate monitor/ unweighted vest. Therefore, it appears that the weighted vest was effective in decreasing off-task behaviour, based on objective measures, in three participants (Adam, Connor, Evan), and potentially for David as well. Three children (Bobby, Fabian, Grace) showed no effects on objective measures with the exception of one phase of positive CGI-T score change for two of the children. Their aides and teachers reported only some effectiveness of the weighted vest. Hailey also only showed no effects with the exception of one phase of positive CGI-T score change; however, her teacher and aide both reported positive effects with the weighted vest. Table 25 provides a summary of all objective and subjective data.

Table 25. Overall data summary

Child	Objective Measures				Subjective Measures	
	Off-task Behaviour	Stereotyped Mannerisms	CGI-T (1st A-B phases; 2nd A-B phases)	Heart Rate	Teacher: Continue Use?	Aide: Was it Effective? Continue Use:
Adam	↓ 22% (PND = 70%)	No effect (motor)	-ve change; +ve change	+ 7 bpm (Visually small effect; PND = 70% increase)	Yes	Sometimes; Maybe
Bobby	No effect	No effect (motor)	+ve change; no change	No effect	Yes	Sometimes; Maybe
Connor	↓ 26% (PND = 70%)	↓ 18% (verbal) (PND = 60%)	No changes across phases	-	Yes	Yes; Yes
David*	↓ 19% (PND = 50%)	-	+ change both phases	- 4 bpm (Visually no effect; PND = 67%)	Yes	Yes; Yes
Evan	↓36% (PND = 70%)	-	No change; subtle +ve change	-11 bpm (Visually no effect; PND = 56%)	Yes	Yes; Yes
Fabian	No effect	-	No change; +ve change	-	Yes	Sometimes; Maybe
Grace	No effect	-	No change; +ve change	No effect	Yes	Sometimes Yes
Hailey	No effect	No effect (motor)	+ve change; -ve change	No effect	Yes	Yes; Yes
Ian	↓27% back to baseline following increase (PND = 80%)	No effect (motor)	No change; +ve change	No effect	Yes	Yes; Yes
Jack *	↓14% with 10% weight (PND = 50%)	No effect (motor)	-ve change; +ve change	-	Yes	Yes; Yes (with 5% weight)

* potential confounds noted that impact confidence that results represent true treatment effect

CHAPTER IV: DISCUSSION

The primary purpose of this study was to examine the effectiveness of an intervention modality, the weighted vest, on targeted behaviours for children with autism. Specifically, we measured the effects of the weighted vest on decreasing off-task and stereotyped behaviours, and increasing sitting time for children with autism in a classroom setting. Behaviour was measured objectively through video analysis and standardized measures of behaviour completed by teachers. We evaluated teacher and aide perceptions of the effects and use of weighted vests in the classroom. We also measured heart rate while the participants wore the vest to test the theoretical basis for the use of weighted vests.

The discussion is presented in eight sections: (a) effects of the weighted vest on behaviour; (b) teacher and aide perceptions of the use of weighted vests in the classroom; (c) effects of the weighted vest on heart rate; (d) implications for current practice; (e) strengths of the study; (f) limitations of the study; (g) directions for future research; and (h) conclusion.

Effects of Weighted Vests on Targeted Behaviours

Effects of Weighted Vests on Decreasing Off-Task Behaviours

The first main finding, based on blinded video analysis, was that weighted vests appeared to be effective in decreasing off-task behaviours in the classroom for some, but not all, of the participants. When the nature of off-task behaviours was investigated, most of the improvements in behaviour were directly related to looking away from the activity. The weighted vest did not appear to influence other measured off-task behaviours, including decreasing the number of prompts required to participate in the activity or playing with the materials.

There was one outlier in Evan’s data, represented by a relatively low percentage of off-task intervals with the unweighted vest on a day when the children were participating in his favourite activity. Thus, Evan’s attention appeared to be significantly improved by his interest in the activity, demonstrating that motivation and interest alone can have a significant impact on decreasing off-task behaviours and improving participation. This highlights one of occupational therapy's core values: the importance in choosing activities that are meaningful to the individual. However, educational activities do not always involve choice. Therefore, when the task and/or environment cannot be modified, interventions targeting underlying mechanisms of attention may have an important role.

Measuring off-task behaviours is a quantifiable way of measuring attention. It is well documented that individuals with autism often have difficulties with attention compared with their peers without autism, including both extreme distractibility and over-focused attention (Greenaway & Plaisted, 2005; Mayes & Calhoun, 2007). Although no child would be expected to have 100% attention at all times, individuals with autism can become so fixated on one stimulus that attention cannot be directed towards a learning activity. Alternatively, individuals with autism can be so highly distracted by environmental stimuli that attention cannot be maintained on a learning activity (Greenaway & Plaisted). The participants were in classrooms with a lot of stimuli, such as movement and background noise. Additionally, the activities during which they were observed were not self-selected, and therefore likely not of special interest, which is likely to decrease focus (Mayes & Calhoun). Given what is known about attention in individuals with autism, it is not surprising that the rates of off-task behaviour were high.

Ian's treatment and withdrawal phases alone indicated one of the most compelling positive treatment effects, nicely demonstrated by the lack of overlap in data between weighted and unweighted phases, and by the large and immediate increase in off-task behaviours between the first weighted and second unweighted phase. However, when compared with his baseline data, it was concluded that the unweighted vest and/or heart rate monitor had a negative effect, which was ameliorated by the weighted vest, but no more so than with no intervention at all. Kane and colleagues (2004-2005) also found that an unweighted vest had a negative impact on attention to task for the participants in their study. They observed that the vest itself was distracting (their participants touched and tugged at the vest), which we did not observe with Ian. Ian did not appear distracted by the heart rate monitor (e.g., he was not observed to touch his chest where the monitor was placed). Given how short Ian's baseline phase was (2 data points), we are left wondering if it provided an accurate representation of behaviour, especially since other behavioural measures indicated positive treatment effects.

Although the weighted vest did appear to have clinically meaningful benefits for some participants, particularly related to decreasing visual distraction from an activity, it did not eliminate off-task behaviour in any participant, nor did its input override all the other experiences in the children's lives that appeared to impact classroom behaviour. This becomes particularly relevant when outlying data are examined for David and Jack. Both of these boys had experiences in their personal lives: illness, changes in home routines, and changes in caregivers, which appeared to significantly impact classroom behaviour. These experiences were beyond our ability to control as researchers, and highlight some of the challenges with intervention research conducted within the context of everyday life. Outlying data highlight that the weighted vest is only one part of the child's experiences, and may not be consistently beneficial for the same child.

Effects of Weighted Vests on Decreasing Stereotyped Behaviours

All behaviours that were coded as stereotyped behaviours in this study fit the definition put forward by Baumeister and Forehand (1973, as cited in Kennedy, Meyer, Knowles & Shukla, 2000) of repetitive movements or behaviours that do not appear to serve an adaptive function. These repetitive behaviours included motoric (rocking, twirling objects, flicking objects, hand and finger mannerisms) and verbal (delayed echolalia) behaviours. Typically when weighted vests are implemented to help reduce stereotyped behaviours, it is based on the assumption that the behaviours are a child's attempt to calm and modulate arousal during stressful activities or in stressful environments (Tomchek, 2001; Rogers & Ozonoff, 2005). Since weighted vests are thought to provide sensory stimulation to help modulate arousal, theoretically they could replace this function of a stereotyped behaviour. However, we did not see a decrease in motoric stereotyped behaviours in any participant, even in those participants who demonstrated decreased looking away with the weighted vest. This suggests that the motoric stereotyped behaviours demonstrated by the participants did not serve the arousal modulation function purported by users of weighted vests, or, if the behaviours were modulatory, this input was not replaced by touch-pressure input provided through the weighted vest as suggested by sensory stimulation theory. In either case, the use of weighted vests to decrease motoric stereotyped behaviours in the participants was not supported.

The behaviours exhibited by the participants primarily fit into the “elation” category put forth by Willemsen-Swinkels and colleagues (1998), which was speculated to serve as an outlet for excitement or for the direct reinforcement it provides, and not for arousal modulation. There is evidence to support the operant behaviour theory for stereotyped behaviours, which infers that the behaviours are self-stimulatory in nature, maintained by the direct sensory feedback they provide (Cunningham & Schreibman, 2009). Although this function of stereotyped behaviours is sensory-based, it is not intended to serve the same calming and modulating function purported by many users of weighted vests (Morrison, 2007; Olson & Moulton, 2004a; Stephenson & Carter, 2009). The sensory feedback function of stereotyped behaviours appears plausible for the participants who exhibited motoric stereotyped behaviours, given that the behaviours occurred across activities and environments (e.g., calm days, busy days). Additionally, most self-stimulatory behaviours exhibited by the participants provided more than just tactile and proprioceptive input. For example, hand and finger mannerisms, hand flapping and flicking also provide visual input.

Connor’s decrease in verbal stereotyped behaviours with the weighted vest could potentially provide support for the arousal modulation hypothesis. Although Connor was the only participant who demonstrated verbal stereotyped behaviours (as opposed to motoric stereotyped behaviours), and the only participant for whom the weighted vest appeared to decrease his stereotyped behaviour, the nature of Connor’s stereotyped behaviours may not be relevant. Rather, personal characteristics are more likely to have influenced treatment response. Of all the participants, Connor was the most likely to appear agitated and have emotional outbursts. For example, Connor would yell, bang his desk or the wall, throw his chair, and turn over his school desk if he became upset. These outbursts could be provoked by asking Connor to do something he did not want to do (e.g., put a preferred activity away), or could occur seemingly unprovoked. These personal characteristics become potentially important when discussing treatment response to weighted vests because previous research on the effects of deep pressure input and personal accounts of the calming effects of deep-pressure input suggest that this type of input may be most effective for individuals who are anxious or agitated (Edelson et al., 1999; Grandin & Scariano, 1986). Anxiety and agitation are represented by physiological over-arousal, such as increased heart rate (Goodwin et al., 2006). Thus, the arousal modulation theory for weighted vests would be supported if the weighted vest resulted in decreased heart rate for Connor. Unfortunately, he would not wear the heart rate monitor; hence, we do not know if his heart rate decreased during phases when the vest was weighted.

The Effects of the Weighted Vest on Sitting

Sixty-five percent of occupational therapists surveyed have used weighted vests to target sitting, and almost 80 % of these occupational therapists reported that weighted vests resulted in an improvement in a child’s ability to stay seated (Olson & Moulton, 2004a). However, in the present study none of the three participants for whom sitting was measured demonstrated improvement in sitting with the weighted vest.

When the subjective impressions from each child’s aide, not blinded to treatment phase, were analyzed, positive effects of the weighted vest on sitting were reported for two participants. For David, sitting was not identified (and, therefore not measured) as a problematic behaviour. However, his aide reported that the weighted vest enabled him to remain seated with fewer prompts. Perhaps sitting was a less problematic behaviour than behaviours such as wandering or gazing into space identified for David, but became an unanticipated benefit of the weighted vest, deemed clinically meaningful by the aide.

Jack did not demonstrate a difference in sitting based on visual analysis or PND statistics because there was a lot of overlap between phases. However, his aide perceived that the weighted vest helped improve sitting at 5% weight, but not 10% weight. Jack did demonstrate four days in a row of 100% sitting during the phase with 5% weight in the vest. He did not demonstrate more than two days of 100% sitting in any other phase, nor did he demonstrate two consecutive days of 100% sitting. Therefore, a vest with 5% weight may have been beneficial for Jack, but not captured based on the way we analyzed the behaviour.

Teacher and Aide Perceptions of the Effects of Weighted Vests

The Conners Global Index – Teacher (CGI-T) provided a standardized measure of teacher's perceptions of behaviour during each phase. Additionally, the teacher and aide questionnaires, completed pre- and post-intervention, provided valuable subjective information related to perceived clinical effects of weighted vests for children with autism in the classroom setting. Teachers were blinded to treatment condition; therefore, the CGI-T scores were not influenced by expectations. Overall, the CGI-T did not show improved scores during the weighted conditions compared with the unweighted conditions. The CGI-T asked questions specific to restlessness, inattention, short attention span, distraction, and fidgeting. Therefore, it measured behaviours that aligned with the objective behavioural measures.

Although teachers were asked to "consider the last week, when (the child) was wearing the vest", it is possible that teachers responded based on the child's behaviour in general. If the effects of the weighted vest were transient, they may not have been captured in the teacher's report on the CGI-T. The CGI-T has demonstrated sensitivity to short term treatment effects for children with autism. Most of these studies involved medication effects, which may have been larger than the effects from weighted vests. For Evan, Ian and Jack, a decrease in off-task behaviour corresponded with CGI-T scores indicating less problematic behaviour for only the phase that demonstrated less overlap based on visual analysis. Perhaps the CGI-T is not sensitive to subtle behavioural effects, but is sensitive to more obvious behavioural effects.

Interestingly, the only participant for whom the CGI-T corresponded with the behavioural evaluation across phases was the one child who was fully integrated into a regular classroom, David. David's teacher might have compared his behaviour with his peers without autism, whereas teachers from segregated settings might have compared participants' behaviours to their peers, who also had disabilities that significantly impacted function. Perhaps behavioural changes that occurred within an integrated setting were more sensitive to change. Additionally, although all of the participants were identified as having attention problems and required individual support to participate in the activities, CGI-T scores for many of the participants indicated that their behaviour should not raise concern. Teachers in segregated settings could have different perceptions of, or a higher tolerance for, problematic behaviours. If they never work with children without disruptive behaviours, they may not realize what is normal for a child without autism of the same age or developmental level.

Important subjective information was gathered from both teachers and aides regarding the use of weighted vests for children with autism in the classroom. Because teachers were blinded to treatment condition in each phase, they were not able to comment on observed treatment effects during the study. However, they did provide comments about their overall impressions of weighted vests prior to and following data collection. Aides' impressions of the effects of weighted vests were not blinded, which enabled them to directly relate perceived outcomes to the effects of the weighted vest. Approximately 60% of the teachers and aides involved in the study had used weighted vests before. Most of them reported positive effects in only 50% of the children with whom they had previously used weighted vests. However, they all reported positive effects, at least sometimes, in 100% of the participants. Moreover, perceived benefits included the behaviours we measured, even when we did not see an effect based on video analysis. The teachers and aides who had not used weighted vests before also reported positive benefits in all children with whom they were involved. Therefore, it appears that aides and teachers saw something subjectively that we did not capture from video analysis or the CGI-T.

The video analysis employed in this study and data collection methods of the other studies that have measured behavioural effects of weighted vests have all measured change in an all-or-none approach. For example, the rate of off-task behaviour was measured, but the degree to which a child was off-task was not taken into account. In other words, behaviour was quantified, but the quality of behaviour was not measured. The results from these objective evaluations have not provided overwhelming support for the effectiveness of weighted vests. Alternatively, anecdotal reports from individuals with autism (e.g., Grandin, 2006; McMullen, 2001); parents of children with autism (e.g., Brockmeyer, 2001), and therapists who use weighted vests (e.g., Olson & Moulton, 2004a, 2004b), indicate that weighted vests are effective interventions to help children focus. These anecdotal reports may describe qualitative changes that enabled children to participate in activities, which have not been captured in current empirical investigations of the effects of weighted vests.

Alternatively, teachers' and aides' perceptions of benefits could have been biased by their expectations, conscious or unconscious, regarding what the weighted vests would do (Steward-Williams & Podd, 2004). Teachers and aides often look to occupational therapists for advice on how to deal with disruptive behaviours, and are most commonly provided education and intervention strategies based on sensory processing theory (Case-Smith & Miller, 1999; Watling et al., 1999). Although none of the participants were concurrently using weighted vests or other sensory-based interventions, all of the teachers involved had received consultation from an occupational therapist in the past. Expectancy effects have been shown with other treatments for children with autism. For example, a double-blind, placebo-controlled study of gluten-casein free diets for children with autism revealed no differences between the treatment and placebo (regular diet) conditions. However, parents in the both groups reported improvements in their child's behaviour, and almost 70% of the families (9 of 13) continued the gluten-casein free diets, even after they were informed that the study revealed that it was not effective (Elder, Shankar, Shuster, Theriaque, Burns & Sherrill, 2006).

Finally, it was interesting that all aides reported at least some positive benefits and all teachers and aides reported that they wanted to continue using the weighted vests, yet only three children actually used the weighted vest once data collection was finished. As indicated in Table 24, one teacher was waiting to hear the results of the study prior to implementing weighted vests and one teacher was trying a different type of vest with a participant. The lack of follow through for the other three participants indicates that the perceived benefits were not substantial enough to warrant implementing the weighted vest after the completion of the study or were not more effective than other strategies. For two of these three participants, the effects were seen as only sometimes effective.

Effects of Weighed Vests on Heart Rate

Overall, the weighted vest did not have a clinically meaningful effect on heart rate. Three participants – Adam, David and Evan – demonstrated a difference in heart rate with the weighted vests based on PND statistics, but visual analysis indicated that only Adam demonstrated a difference in mean daily heart rate with the weighted vest. Interestingly, Adam's heart rate increased with the weighted vest, which was contrary to our initial hypothesis that the weighted vest would result in a decrease in heart rate. Evan's data shows an upward trend in heart rate during phase 1. Therefore, Evan's difference between phase 1 and phase 2 cannot be interpreted as being due to the weighted vest.

Our pilot study provided results that suggested that weighted vests decreased heart rate; however, there was no desensitization period to the heart rate monitor or vest. Therefore, those results might have been confounded by an initial increase in heart rate due to a stress response to the heart rate monitor and/or vest, and the observed decrease in heart rate may have been a return to baseline, and not due to the weight (see Appendix G). Heart rate has been used successfully to measure physiological stress responses to sensory stimuli in individuals with autism. However, the method employed in these previous studies, which was the same method used in this study, essentially measures sympathetic influences to the heart (Goodwin et al, 2006; Groden et al., 2005). It has been suggested that weighted vests increase PNS functioning to improve physiological homeostasis, which improves a child's ability to participate functionally in daily activities (Lane, 2001; VandenBerg, 2001). Although physiological homeostasis reflects a balance of activity between the SNS and PNS, and therefore one would expect SNS to decrease if the weighted vest did provide a calming influence, PNS activity can be isolated through heart rate variability, and has been shown to change during stress conditions when overall heart rate did not change (Mulder, 1992). Our measure of heart rate did not allow for isolation of PNS input. Therefore, we are not able to test this hypothesis.

Firm touch-pressure input is thought to be more effective in individuals with initially higher levels of stress and anxiety (Edelson et al., 1999; Krauss, 1987). Therefore, if our sample was not anxious/stressed, but rather under-aroused, we would not expect a decrease in heart rate with the weighted vest. The majority of the patterns of sensory processing indicated by the Sensory Profile School Companion suggest that our participants may have been under-aroused (seeking and registration). This is consistent with the current literature on sensory modulation dysfunction in individuals with autism, which suggests that hypo-arousal and under-responsivity are the most unique and prominent type of sensory modulation dysfunction in individuals with autism. Therefore, if weighted vests are not appropriate for individuals who are under-responsive to sensory input and under-aroused, which is consistent with the most commonly accepted theoretical basis for this intervention, the high rate of weighted vest use with this population is not warranted.

The metabolic demands of activities also underlie stimulation of the heart. For example, if someone participates in the same activity, at the same rate and for the same duration while carrying an increased load of 5% body weight, his heart will have to work harder to meet the increased metabolic demand associated with the increased weight.

Therefore, it is possible that Adam’s heart rate increased with the weighted vest due to the increased metabolic demand from carrying the increased load. Typically developing children demonstrated an increase in heart rate of approximately 8 bpm while wearing a backpack with 10% bodyweight when standing still (Hong, Li, Wong & Robinson, 2000). Increased metabolic load may have also confounded the heart rate data for other participants for whom the weighted vest might have had a physiological effect, but did not show any change in heart rate with the weighted vests. In other words, an effect of the weighted vest on decreasing heart rate combined with the increased metabolic demands of increased heart rate due to carrying increased load could have created a wash out effect of no heart rate response.

Theoretical Assumptions

Sensory stimulation theory proposes that touch-pressure input can promote an optimal level of arousal to support attention, learning and participation (Bundy & Murray, 2002). However, for many of our participants the touch-pressure input provided through the weighted vests was not appropriate and/or sufficient to override the other types of sensations that were distracting in the classroom. For example, some participants were just as likely to be distracted by visual and auditory stimuli with and without the vest. Additionally, physiological indicators in this study did not support the hypothesis that the touch-pressure input provided by weighted vests decreases arousal in children with autism and sensory modulation disorder.

The underlying theoretical assumptions for the use of weighted vests are based on hypothesized functioning within a neurologically intact nervous system. For example, sensory integration theorists propose that touch-pressure input is able to over-ride other arousing inputs, such as auditory, visual and light-touch stimulation because touch-pressure input does not send direct projections to the reticular formation. Therefore, the touch-pressure input reaches higher-order centres quickly, and is able to provide a down-regulating influence on the reticular formation (Reeves, 2001a). Although a potentially overriding influence of deep-pressure stimulation has been demonstrated in individuals with intact nervous systems related to pain pathways (Basbaum & Jessell, 2000), the broad assumption that the input provided through touch-pressure sensory stimulation can provide top-down control over the sub-cortical structures responsible for arousal modulation, emotional regulation and behaviour in individuals is a bold generalization given the pervasive neurological differences reported in persons with autism (Bauman & Kemper, 2005; Courchesne et al., 2005; Courchesne et al., 2007; Kemper & Bauman, 1998; Minshew & Williams, 2007; Rapin & Katzman, 1998; Rapin & Tuchman, 2008; Rubenstein & Merzenich, 2003). Even if weighted vests were shown to have a neurophysiological effect in individuals with intact nervous systems, which has not been tested, the same amount or type of stimuli might not perturb the nervous system in a person with autism in the same way.

The theory of direct influence on parasympathetic functioning is more plausible because low-level processing of sensory information is typically intact in persons with autism (Courchesne et al., 2005). Although the specific neural pathways for this process have not been articulated, direct measurement of PNS function is relatively easy with heart rate equipment that enables calculation of heart rate variability. Direct influence on parasympathetic functioning has not been tested with weighted vests.

Clinical Implications

Responders versus Non-Responders

To help categorize children, we collected a variety of descriptive information prior to data collection. Prior to unblinding, we looked at the descriptive information to see if any preliminary trends for the small sample of 10 participants emerged about who might be more likely to respond positively to weighted vests. Our sample was quite uniform with regard to cognitive functioning, adaptive skills, language skills, and sensory profile patterns. All of the participants had significant cognitive delays, limited or no functional language, moderate to severe delays in adaptive functioning, and similarities in sensory processing patterns indicated on the Sensory Profile School Companion. I did place participants into categories based on my clinical impressions of each child.

Although this final categorization is simply based on my subjective impressions of the child, it is the type of profile many clinicians might use as a basis to recommend weighted vests. These categories included:

(1) very hyperactive/always moving: Bobby, Grace, Hailey, Jack;

(2) under-responsive to sensory input/calmer: Adam, David, Evan, Fabian;

(3) appeared to seek sensory input, but not hyperactive: Connor, Ian

When this categorization was related to potential responders versus non-responders, one potentially important clinical characteristic becomes important: none of the children who were subjectively categorized as being very hyperactive/always moving demonstrated decreased off-task behaviours with the weighted vest. Alternatively, 5 of 6 of the children categorized elsewhere showed apparent or potential positive benefits in decreasing off-task behaviours with the weighted vest. This is clinically important because Olson and Moulton (2004a) found that the most common dysfunction for which weighted vests were recommended, regardless of diagnosis, was hyperactivity. That sentiment was echoed by local occupational therapists. Based on a survey of over 50 pediatric occupational therapists in the Edmonton area, over-arousal (100% of therapists who used weighted vests) and hyperactivity (73% of therapists who used weighted vests) were the most common reasons for recommending a weighted vest. However, based on my subjective categorization of responders versus non-responders, the children most likely NOT to respond are those children who appeared over-aroused and hyperactive.

Short Sensory Profile (SSP) total scores also indicated a potential trend related to responders and non-responders. The SSP represents questions most indicative of sensory modulation dysfunction that affects performance (McIntosh et al., 1999b). Weighted vests are thought to directly affect one's ability to modulate sensory input. A score of 141 or less (out of 190) is interpreted as a definite difference in one's ability to modulate sensory information compared with one's peers. Interestingly, the four participants whose scores fell at the top range of the cut-off for sensory modulation dysfunction demonstrated potential improvements in off-task behaviour with the weighted vest (Adam = 141, Connor = 140, David = 138, Evan = 141). Perhaps weighted vests are most effective for individuals who have less sensory modulation differences. Put another way, perhaps weighted vests, calibrated at 5% body weight, do not provide strong enough sensory input for individuals with significant sensory modulation differences.

Characteristics of the Treatment Protocol

The objective data from this study did not show clear evidence of immediate change in the dependent variables. It is possible that the short data collection period (5 minutes) was not long enough to capture qualitative effects that the aides reported. Additionally, behaviour was recorded early in the activity. Therefore, it is possible that treatment effects were not recorded because a child had not yet adjusted to the vest. The participants in previous research who wore a weighted vest for at least 30 minutes prior to observation consistently demonstrated positive treatment effects (Fertal-Daly et al., 2001; Myles et al., 2004). However, due to methodological weaknesses in these two studies, their results need to be interpreted with caution. The absence of immediate treatment effects contradicts anecdotal reports from therapists that consistently indicate that the effects of weighted vests are seen immediately (Olson & Moulton, 2004b). Additionally, our treatment protocol (wearing schedule, % body weight) mimicked what is most commonly used in current practice. Although one would hope that therapists continue to use the treatment protocol that they observe to be the most effective, therapists may simply imitate what is most commonly used in current practice when empirical evidence for the effectiveness of an intervention does not exist.

Implications for Clinicians

Weighted vests have been adopted as a common remedial strategy for use with children with autism in classroom settings. Although current models and frameworks guiding occupational therapy practice stress the need to consider factors external to the person with sensory modulation dysfunction (Baranek, 2001, 2008; Dunn 1997, 1999, 2002; Miller & Summers, 2001), many therapists continue to focus on remedial approaches (Miller & Summers; Olson & Moulton, 2004a). Additionally, occupational therapists report using weighted vests generically because the theoretical basis is not well-articulated, and specific guidelines do not exist for practice (Olson & Moulton, 2004a, 2004b). Because some participants did show some improvements in off-task behaviour with the weighted vest, this may be a suitable component of intervention for some children. However, the data from this study indicate that focusing solely on this remedial approach is not a clinically responsible approach to improve adaptive behaviour for children with autism and sensory modulation disorder in the classroom. Some participants demonstrated no improvement in behaviour with the weighted vest, and the children who did demonstrate objective and subjective improvements in behaviour still had high rates of off-task behaviour with the weighted vests.

A shift in accommodating to a child's sensory-processing needs, rather than trying to change a child's sensory processing thresholds, is likely to lead to more long-term, successful outcomes. This approach is represented in the models suggested by Baranek (2001, 2008), Dunn (1997, 1999, 2002) and Miller and Summers (2001). For example, if a child with autism becomes upset by the noise and random touch associated with getting ready for recess, rather than trying to change a child's thresholds for noise and touch by using a weighted vest for the transition, he could get his coat and boots on one-minute before the other children, thereby avoiding the noise and tactile stimulation. However, in some situations, the task and/or environment cannot be changed to eliminate the bothersome stimuli. For example, a child with autism will need to participate in circle time at pre-school. In this situation, random touch stimuli could be decreased through the use of mats to designate seats, and chatter noise could be reduced through the use "talk toy" (a child is required to have this toy in hand before they can ask or answer a question). A weighted vest might be added as one component of multi-faceted interventions put in place to help him participate in circle time.

The theoretical basis for weighted vests assumes that sensory stimulation is not stimulus specific; rather the touch-pressure input provided by weighted vests has a regulatory influence over other stimuli. However, this theory is not supported when stereotyped behaviours are examined. Weighted vests are recommended to provide an overall calming and modulating influence to decrease stereotyped behaviours, regardless of their form (Olson & Moulton, 2004a, 2004b; Stephenson & Carter, 2009). We did not find that weighted vests impacted motoric stereotyped behaviours; a result replicating previous research with children with autism (Kane et al., 2004-2005; Deris et al., 2006; Stein, 2007). However, motoric stereotyped behaviours have been successfully eliminated with behavioural intervention (e.g., systematic extinction procedures) when replaced with more socially appropriate means of achieving the same type of sensory stimulation (e.g., mouthing a small string instead of one's hair or finger; Tang, Patterson & Kennedy, 2003). This suggests that stimulus specific input may be more effective than general touch-pressure input.

Intervention targeting stereotyped behaviours is likely to be more effective if we try to replace these behaviours with a more functional behaviour of the same type (sensory specific) than use weighted vests to decrease the behaviour (Cunningham & Schreibman, 2008). For example, if a child consistently hums or makes noise for auditory feedback, he can be provided with a musical toy or MP3 player as an alternative. Along the same lines, a child who always spins objects for visual feedback can be provided with non-contingent access to a small spin top (Cunningham & Schreibman). This reinforces that intervention is likely to be more effective if we accommodate to a child's needs.

Strengths of the Study

Stephenson and Carter (2009) stressed the need for future research related to the effects of weighted vests for children with autism to include detailed participant descriptions, rigorous inter-observer reliability, blinded observers to treatment condition, consideration of the functional magnitude of changes, and more stringent research designs than have been typically employed. This study was much more rigorous than previous research related to the effects of weighted vests for children with autism. Raters were blinded to treatment condition and adequate inter-rater reliability was established using Kappa statistics, which is considered the superior reliability index for behavioural research (Watkins & Pacheco, 2000). We had good communication regarding potential confounds, both within and outside of the classroom, which was taken into account when interpreting the results. Each child's aide, teacher and activities were consistent, and treatment fidelity was very good for 9 of 10 participants. We also have detailed descriptive information on all participants, which enables one to generalize the results to similar children and enables replication to improve external validity.

The results of this study have direct clinical applicability because the intervention took place within the child's natural classroom environment. This is important since the behaviour of children with autism can be significantly affected by their environment (Dunn, 2008). Therefore, intervention research conducted in research settings may not generalize to real life environments. We were able to sample the age range for which weighted vests are most often recommended, a variety of classroom settings, including segregated and inclusive settings, and a variety of teaching and aide styles of interaction.

The inclusion of various types of behavioural data (video analysis, standardized questionnaires, and subjective reports) provided a holistic picture of the potential impact of weighted vests for children with autism. Including only one measure, or one type of measure, might have missed meaningful information.

Limitations

Targeted behaviours. Results are limited to the dependent variables that I chose to measure. These behaviours were chosen because they were the most commonly targeted behaviours as reported by clinicians, they were reported as problematic by teachers and educational assistants, and they were commonly reported on in other studies. However, there was no empirical evidence indicating that only the targeted behaviours would change. Children with autism do not always respond to interventions in a predictable way; therefore, it is possible that the weighted vest had an effect on behaviours that were not measured in this study.

Confounds. There were two participants who had events occur in their day to day lives that potentially confounded their response to treatment and limited our ability to make conclusive statements about effects. Their data was interpreted considering these confounds, and was reported conservatively. However, this may have resulted in an under-reporting of treatment effects.

Phase length and phase shifting. In single-case research, behaviour within a phase should be relatively predictable, without trend or slope, before moving to the next phase (Bailey & Burch, 2002). Therefore, the length of each treatment phase should not be pre-determined; rather, conditions should be changed once responses are consistent (Horner et al., 2005). Due to the rules and regulations around conducting research within the school system, we had limited time during which we could collect data within the classrooms. Therefore, we pre-determined phase length based on the available time to ensure that we had three opportunities for demonstrations of experimental effect (BCBC phases), which is the minimum recommended for experimental control in single-case research designs (Horner et al.). However, this was a significant limitation of the study because there were some cases when we switched phases prior to achieving stability during B phases. Our inability to predict future behaviour due to variable data decreased internal validity of the study because we could not be confident that changes in behaviour were isolated to effects of the weighted vest and not an unknown variable for all participants.

Additionally, time constraints due to the rules and regulations around conducting research with the school system resulted in a short phase A (without vest or heart rate monitors) of 2 or 3 data points for each participant, which is less than the minimum of 5 data points per phase recommended by Horner and colleagues. Additionally, phase A data was variable for many of the participants, which limited our ability to discuss possible effects of the equipment alone on behaviour. Fortunately, when baseline data were variable or trending appeared, it was generally in the opposite direction of the expected treatment effect (e.g., David, Grace, Hailey). However, this does present a significant problem in interpreting Ian’s results. Ian only had 2 baseline data points, which is generally not considered sufficient to determine a predictable pattern of behaviour (Horner et al.). Based on his baseline data, we concluded that the treatment had a negative effect on Ian. However, this conclusion is not accurate if the baseline data is not accurate. The inclusion of a longer phase A, with time to reach stability, and the inclusion of an additional phase A (i.e., ABCABC) would have made potential influences of the equipment alone clearer.

Participant Characteristics. Our sample was quite homogeneous related to language levels, adaptive functioning and cognitive ability. However, weighted vests are also used with children who present differently, including children with functional language, children without cognitive delays, and children with higher adaptive functioning. The results of this study cannot be used when considering these groups of children with autism.

Method of Data Analysis. Partial interval recording is recommended for behaviours that can be difficult to observe and relatively short in duration, such as looking away from school work (Bailey & Burch, 2002). However, partial interval recording is likely to result in false-negative interpretations of data, particularly for high-rate behaviours of short duration (Meany-Daboul, Roscoe, Bourret & Ahearn, 2007). Put another way, partial-interval recording tends to underestimate treatment change and may not detect small treatment effects that could be clinically meaningful. Partial interval recording also does not account for decreases in the potency of a disruptive behaviour (for example, how vigorously a child engaged in stereotyped behaviour), which may have contributed to discrepancies between objective and subjective outcomes. This potentially conservative estimate of change might have contributed to the discrepancies between objective video analysis, which identified limited effects of weighted vests on behaviour, and teachers' and aides' subjective impressions of weighted vests, which indicated clinically meaningful treatment effects.

Percent non-overlapping data (PND) is the most widely accepted metric for calculating the magnitude of effects in single-case research (Stephenson & Carter, 2009). However, because PND ignores all baseline data points except one data point, it may underestimate the magnitude of the treatment effect (Campbell, 2004; Parker & Hagan-Burke, 2007). However, other available methods of analysis are considered more problematic than PND (Stephenson & Carter, 2009), and therefore were not chosen for this analysis. For example, using only the average score within phases can decrease the appearance of variability, resulting in over-reporting of treatment effects. Additionally, standards of what constitutes a meaningful mean difference are not yet established (Olive & Smith, 2005). The two standard deviation methods can result in inflated effect sizes (Leong & Carter, 2008), and the binomial test can result in increased false-positives (difficulty controlling for type one errors; Stephenson & Carter). Visual inspection should always be the primary method of data analysis in single-case design, and effects that are not apparent on visual inspection but revealed by statistical techniques are not suggestive of clinically effective interventions (Kazdin, 1982; Stephenson & Carter). Visual analysis was the primary indicator of treatment effect in this study, supported by PND. Therefore, I am confident that I did not overestimate treatment effect; however, I may have provided a conservative estimate of treatment effect in some cases.

Inter-rater Reliability. Although the average Kappa was above the recommended guideline of 0.60 for all participants, there were some inter-rater reliability coefficients that were quite low. Raters were blinded to treatment condition; therefore, rater bias should not have impacted results. It is possible that agreement varied due to changes in participant behaviour over time, rater behaviour over time, or a lack of clearly defined behaviours (Kazdin, 1982). There were clearly defined behaviours and a high level of inter-rater agreement was established prior to commencing the study. Upon review of the videos with poor initial inter-rater reliability it was noted that most disagreements were when the second rater missed very brief behaviours. Regardless, the participant's behaviour may not be accurately represented for the days with low Kappa coefficients, which could change the overall picture of treatment effectiveness. Inter-rater reliability will be re-evaluated prior to further publication of the data.

Sensitivity of Measures. Sensitivity to treatment change is a crucial requirement of an outcome measure (Fitzpatrick, Ziebland, Jenkinson, Mowat & Mowat, 1992). Intervention research involves a balance between operationally defining and identifying variables that are quantifiable and measureable, and discerning treatment effects that are clinically meaningful. Subjectively, all teachers and aides reported meaningful behavioural changes with the weighted vests that were not always captured by more objective measures including visual analysis, PND statistics and the CGI-T. Therefore, it appears that some of our outcome measures may not have been sensitive enough to capture clinically meaningful treatment effects.

Physiological measures. Although heart rate has been deemed a robust measure of general physiological arousal, it does not provide information about the responsible mechanisms since it is under joint control of sympathetic and parasympathetic influences (Goodwin et al., 2006). The advantages of the Polar Vantage XL heart rate monitor were that it was affordable, and easy to wear and use within a regular classroom setting. However, it was not able to isolate PNS activity (personal communication, Stephen Porges, November 14, 2006). A more sophisticated measure of autonomic activity, such as heart rate variability, which enables the isolation of PNS input through the calculation of vagal tone, may have provided more insight into the effects of weighted vests on underlying mechanisms.

Directions for Future Research

The results of this study can help refine methodology in future studies, and provide new directions for future research. Our objective results indicate that weighted vests may have clinically meaningful effects for some, but not all children with autism, yet our subjective results support the use of weighted vests with all the participants. Therefore, our results mirror the current state of research: that the effectiveness of weighted vests for children with autism remains inconclusive at this time. Our inconclusive results are in spite of meeting the methodological demands for future research put forward by Stephenson and Carter (2009). Given the discrepancies in results thus far, even in studies with acceptable methodological rigor, more of the same will not provide clarification about the effects of weighted vests for children with autism. However, the following studies may help advance the field related to interventions targeting sensory modulation disorder in children with autism.

1. There have been discrepancies in the results between studies on the effects of weighted vests that did and did not include blinding procedures, and between objective and subjective reported of treatment effects. Given these discrepancies, a systematic evaluation of the impact of placebo effects, or “expectancy bias”, would provide interesting and meaningful information to both the research and clinical communities. This could be achieved with a comparative study, where children with autism would be observed without and with a vest. Although observers (therapists, teachers and/or aides) would be told that the vest was weighted, it would actually have no weight. Raters would provide subjective ratings of effectiveness. Additionally, a measure of the observers pre-existing opinions of weighted vests would provide important information.

2. If the study described in item 1 shows no placebo effect then future work should consider different ways to measure behaviour. The current body of research on weighted vests has used similar outcome measures, which has not resulted in objectively measured treatment effects consistent with subjectively reported treatment effects. Goal attainment scaling (GAS) has been recommended as a sensitive, reliable and valid outcome measure for sensory-based treatments (Mailloux et al., 2007). GAS was used in a pilot study examining the effectiveness of occupational therapy using a sensory approach for children with sensory modulation disorders, and was found to be more sensitive to treatment effects than both standardized questionnaires and physiological measures (Miller, Coll & Schoen, 2007). Incorporating GAS into a study on the effects of weighted vests, or other sensory-based or multi-faceted approaches, might provide a systematic way to capture meaningful, functional outcomes noted by parents, teachers, aides and therapists, that have not been captured in the research to date. However, it is critical to include blinding of treatment condition to avoid placebo effects that would not be captured by unblinded GAS.

3. These results are limited to the behaviours I chose to measure. Open coding of the same videos used in this analysis might suggest additional behaviours to investigate, revealing treatment effects for behaviours that were not initially measured (e.g., general affect, body posture).

4. The theoretical basis for weighted vests, and other touch-pressure interventions, is based on changes at the neurophysiological level. Although we did not see physiological effects from the weighted vests, even in children who demonstrated behavioural improvements, our measures of physiological response did not isolate the influence of the PNS. Future research that includes heart rate variability and cardiac vagal tone (indicators of PNS activity) is feasible and could provide important insight into the theoretical basis for weighted vests or other touch-pressure interventions. Some of the heterogeneity inherent in persons with autism can be controlled by sub-grouping children with autism based on neurophysiological responses to sensory stimuli, similar to the methods of sub-grouping children with sensory modulation disorder used by Miller and colleagues (McIntosh et al., 1999; Miller et al., 1999; Schaaf et al., 2003). For example, children could be exposed to pre-determined auditory, visual and touch stimuli and neurophysiological responses could be measured, indicative of sensory modulation subgroups (i.e., over- or under-responders based on heart rate, heart rate variability, cortisol, blood pressure, electrodermal response). Then the impact of touch-pressure input on PNS function could be measured in these homogeneous subgroups of children.

5. Although the study described above in item 3 has the potential to expand the theoretical basis for weighted vest use, physiological responses need to be linked with functional outcomes before weighted vests could be endorsed as an effective treatment strategy. This is similar to research done on massage therapy, which has linked massage to increased vagal tone *and* improved attention. If positive responders are found based on physiological responses, and if physiological responses can be linked to observable

behaviours or to a screening questionnaire, a ‘positive predictive profile’ for weighted vests might be feasible.

6. Rather than continuing to research the effects of weighted vests or other remedial strategies in isolation, research is needed that investigates the relative contribution of different strategies within a multi-faceted, comprehensive approach. For example, the relative contribution of remedial strategies and task/environmental modification, versus the combination of remedial and modification approaches. Although a more holistic approach that recognizes the impact of context on behaviour and function makes intuitive sense to occupational therapists, the effectiveness of this approach on functional outcomes for children with autism has not been empirically studied.

Conclusions

A substantial amount of non-peer reviewed information is now available on the internet and in popular press publications, which has created additional demands for occupational therapists to include sensory-based approaches, including weighted vests, in their practice (Miller, Coll & Schoen, 2007). However, empirical research on the effects of weighted vests for children with autism, including this study, has produced inconclusive results (Stephenson & Carter, 2009). Additionally, the children for whom occupational therapists most commonly recommended weighted vests, those who appear over-aroused and hyper-active, might actually be the least likely to have changes in objective behaviours, at least as measured in the current study.

Weighted vests are commonly used with children with autism to decrease difficulties with sensory modulation to improve classroom function and participation. This study has provided the most rigorous evaluation to date of the effects of weighted vests on classroom behaviour for children with autism. It is also the first study to attempt to evaluate the theoretical basis for weighted vests by measuring their effects on underlying mechanisms in natural settings. The results provided a mixed picture of the effectiveness of weighted vests on decreasing off-task behaviours for children with autism. Although weighted vests are reported to be used clinically to decrease motoric stereotyped behaviours, results do not support the use of weighted vests for this purpose.

Overall, participants still demonstrated difficulties with adaptive behaviour, even when positive effects were noted with the weighted vests. I do not go as far as Stephenson and Carter (2009) who have recommended that weighted vests should not be used in clinical practice; however, I do recommend that weighted vests are not used in isolation. I recognize that placing the emphasis on changing factors that are internal to the child, for example changing his or her sensory threshold, is not likely to strongly influence functional behaviour. Rather, I support more holistic approaches to practice that attempt to accommodate to a child’s sensory needs rather than change a child’s sensory thresholds. I hope that the knowledge gained from this study, and the limitations identified within this study will be used to inform future research investigating the effectiveness of interventions targeting sensory modulation dysfunction in children with autism.

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Appendices

Appendix A: Cooperative Activities Program (CAP)Research Project Application

SCHOOL DISTRICT (Please choose only one school district unless it is crucial to your research that you involve more than one)

___Edmonton Public   Elk Island Public (Sherwood Park & area) ___

___Edmonton Catholic   St Albert Protestant ___

Title of Research -	Date submitted –
Proposed start date -	Proposed end date (final report) -

APPLICANT (University Staff Member) (please print clearly)

Name -	Faculty -
Position -	Department -
Campus address -	Phone -
Email -	Fax -

Applicant signature ________________________ (If applying on behalf of a student, my signature indicates that I have read this application, and approve its submission.)

Is this request being made on behalf of a graduate student?___ YES ___ NO
undergraduate student?___ YES ___ NO

If yes, indicate - ____

Student's name -	Phone -
Email -	Department -
Address (complete mailing address if campus address not available) -	

FOR OFFICE USE ONLY

University review - ☐Approved ☐ Denied   Date ________________________

Ingrid Johnston, Associate Dean, Research

District review - ☐Approved ☐ Denied   Date ________________________

District Contact person - ____

REQUEST FOR SCHOOL (DISTRICT) ACCESS

1. Description of how this activity is of value to the school(s) or school district(s) involved.

Why should the school district grant your request? Explain how your proposed research will be of direct and specific benefit to the school, students, teachers, administrators and/or school district(s) involved.

2. Suggested personnel, school and times.

Be specific about the anticipated duration of your study and the number of visits involved. If possible, list the schools you would like to work with, and identify teachers, numbers of subjects, grade levels, etc.

3. Anticipated project timeline and completion date of final report.

When creating timelines for conducting research in schools, remember to include four to eight weeks for processing of this application, and sufficient time for completing the final report. The completion date should not go beyond the end date of the ethics approval.

UNIVERSITY ETHICS APPROVAL

All proposed research projects involving human participants must be approved by the Research Ethics Board (REB) of the appropriate Faculty prior to submission of a CAP request. Inquiries regarding the procedures established for research ethics review should be directed to the project initiator's department/school/faculty. Attach the research proposal submitted to the REB in its entirety, and notification of approval, to this application.

SUBMISSION CHECKLIST

CAP Application cover sheet	___attached
Request for school (district) access	___attached
University ethics proposal and approval	___attached ___not applicable

****

Inquiries regarding the Cooperative Activities Program (CAP) should be directed to Betty jo Werthmann (492-2261) or betty.jo.werthmann@ualberta.ca.

The personal information requested on this form is collected under the authority of Section 33(c) of the Alberta Freedom of Information and Protection of Privacy Act for administrative purposes only.

Appendix B: Recruitment Poster for Parents

UNIVERSITY OF
ALBERTA

Department of Occupational Therapy
Faculty of Rehabilitation Medicine

2-64 Corbett Hall www.ot.ualberta.ca Tel: 780.492.2499
Edmonton, Alberta, Canada T6G 2G4 Fax: 780.492.4

Is your child diagnosed with Autism?
Does your child have trouble paying attention at school?

Will you help us to test the effects of an intervention…the WEIGHTED VEST?

VOLUNTEERS NEEDED!

We want to see if and how weighted vests work! Studying this treatment will help occupational therapists, families and caregivers of children with autism and, most importantly, children with autism.

The study will take place in your child's classroom. Your child will not miss any activity or educational time and very little extra time will be required on your part.

If you would like to learn more please return the attached form in the envelope provided and we will contact you with more information.

PLEASE NOTE: You do NOT have to participate in the study by returning this form. You are only showing interest.

Response form for more information about weighted vest study

Parents Name: ______________________

Child’s Name: ______________________

Child’s Age: __________

Child’s School: ______________________

Child’s Program: ______________________

Child’s Teacher: ______________________

Address (to send information package):

____

____

Telephone: ______________________

E-mail: ______________________

Thank you for your interest in this important research!

Appendix C: Information Letter for Parents

UNIVERSITY OF ALBERTA
Department of Occupational Therapy
Faculty of Rehabilitation Medicine

2-64 Corbett Hall www.ot.ualberta.ca Tel: 780.492.2499
Edmonton, Alberta, Canada T6G 2G4 Fax: 780.492.4628

Information Letter for Parents/Legal Guardian of Participants in the Weighted Vest Study

Study Title: *The effects of weighted vests on behavior and heart rate for children with autism.*

Investigators:
Joyce Magill-Evans, PhD (492-0402) & John Misiaszek, PhD (492-6042)
Department of Occupational Therapy, Faculty of Rehabilitation Medicine, University of Alberta
Sandra Hodgetts, MClScOT, Doctoral Candidate
Faculty of Rehabilitation Medicine, 3-48 Corbett Hall, University of Alberta, Edmonton, T6G 2G4
Telephone: (780) 492-8568
E-mail: sandra.hodgetts@ualberta.ca

Location:
This study will take place in your child’s classroom.

Background:
Weighted vests are used to help children with autism pay attention. Some children with autism notice all the sensory information around them. For example, a child might be distracted in a noisy room, or a room with lots of people or books. The input from a weighted vest might improve attention by calming a child. This helps the child make better sense of information in their environment. We think it might affect a child’s nervous system. Although weighted vests are often used, we do not know how well they work or why they work.

Purpose:
This study will determine if your child pays more attention when wearing a weighted vest. We will also see if the weighted vest affects heart rate.

Procedures:
You will be asked to fill out a questionnaire. This will take about 10 minutes. This will tell us if your child processes information in a way suitable for our study. We will tell you if your child is not suitable for this study. If your child is suitable, he will receive a vest and a heart rate monitor to play with at school. This will let your child become familiar with the equipment. We might contact you during the study to see if your child has changed medications.

At school your child will wear a heart rate monitor for about 20 minutes two to three days per week for 8 weeks. The monitor is a rubber strap that fastens to sticky pads on the chest or back, under clothing. The strap is safe and commonly used. It should not interfere with any school activities. Your child’s heart rate will be monitored when wearing and not wearing a weighted vest. Some weeks we will add weights to the vest. This will be 5% of your child’s weight. Some weeks we will not add weight to the vest. The heart rate monitor or vest will be removed if your child does not want them on any longer.

When your child is wearing the monitor he or she will be videotaped. This will let us look at the link between heart rate and behaviour when we are outside of the busy classroom. Only the researchers will see the videotapes.

Your child's aides will also complete a questionnaire. This describes how your child responds to sensory information in the classroom. The teacher will complete a short checklist every two weeks to describe your child's activity level and attention.

Confidentiality:
Only the research team will see your child's information including the videotapes. Your child's name will be removed from all documents. Only numbers will be used on the records. Any information that you provide on your child, or that we record, will be kept confidential except when professional codes of ethics or legislation require reporting. All information will be kept in a locked filing cabinet. All information will be kept for a minimum of five years after the study is complete. Information and findings from this study may be presented at conferences and be published. Any information that might identify you child will not be used.

Study Results:
Information collected in this study may be looked at again for another study. Approval to do this will be sought from the Ethics Review Committee first. If this happens, all information about your child will be kept confidential.

Possible Benefits:
This study may lead to better treatments for children with autism. It is possible that the children in this study will feel calmer and be less distracted with the weighted vest.

Possible Risks:
There are no known risks. Your child will not be harmed. No change in occupational therapy services through Alberta Learning will occur as a result of being in this study.

Voluntary Participation:
If you decide your child can participate in the study, you can stop at any time by telling the researcher. School services for your child will not change in any way if you choose to withdraw.

Contacts:
If you have any questions about this study, contact Sandy Hodgetts at sandra.hodgetts@ualberta.ca or 492-8568.

If you have any concerns about this study, contact Dr. Paul Hagler, Associate Dean of Research, Faculty of Rehabilitation Medicine at (780) 492-9674.

Appendix D: Proxy Consent Form for Parents

UNIVERSITY OF ALBERTA
Department of Occupational Therapy
Faculty of Rehabilitation Medicine

2-64 Corbett Hall www.ot.ualberta.ca Tel: 780.492.2499
Edmonton, Alberta, Canada T6G 2G4 Fax: 780.492.4628

Proxy Consent Form

Study Title: The effects of weighted vests on behaviour and heart rate for children with autism.

Part 1: Researcher Information

Investigators:
Joyce Magill-Evans, PhD & John Misiaszek, PhD
Department of Occupational Therapy, Faculty of Rehabilitation Medicine, 2-64 Corbett Hall, University of Alberta, Edmonton, T6G 2G4

Sandra Hodgetts, MClScOT, Doctoral Candidate
Faculty of Rehabilitation Medicine, 3-48 Corbett Hall, University of Alberta, Edmonton, T6G 2G4
Telephone: (780) 492-8568 E-mail: sandra.hodgetts@ualberta.ca

Part 2: Consent of Subject

	Yes	No
Do you understand that your child has been asked to be in a research study?		
Have you read and received a copy of the attached information sheet?		
Do you understand the benefits and risks involved in having your child take part in this research study?		
Have you had an opportunity to ask questions and discuss the study?		
Do you understand that you are free to refuse to participate or withdraw your child from the study at any time? You do not have to give a reason and it will not affect any services provided by Alberta Learning.		
Has the issue of confidentiality been explained to you? Do you understand who will have access to your records/information?		
Do you understand that your child will be video recorded?		
Can we use your child's video for teaching purposes?		

Part 3: Signatures

This study was explained to me by: ________________________________ Date: ______________

I agree to have my child take part in this study.

Signature of Parent/Legal Guardian:____

Printed Name: ____

I believe that the person signing this form understands what is involved in the study and voluntarily agrees to have his or her child participate.

Researcher: _________________________________ Printed Name:
____

A COPY OF THIS CONSENT FORM MUST BE GIVEN TO THE PARENT/LEGAL GUARDIAN

Appendix E: Family demographic and information form

The Effects of Weighted Vests for Children with Autism
GENERAL FAMILY INFORMATION

We are collecting this information to describe who participated in general terms. You do not have to answer a specific question if you do not want to.

Date:________________ Name of Person Completing Form:_________________

Relationship to Child:____

Identification Information

Family

Name:____

Name of Child with Autism: ____________________ Date of Birth:_________________

Address:

____

____

Telephone Numbers

Home: _________________ Work: __________________ Other:__________________

E-Mail:____

Family Information

Primary Language Spoken at Home: ____

Other Language(s) Spoken: ____

What is your family's cultural or ethnic background? (e.g., Italian, Métis, Cantonese, English Canadian) ____

Child's Parents Are (circle one): Married Divorced Separated Other

With whom does the child currently live? (please list)

Name	Age/Date of Birth	Relationship (e.g., mother, brother, aunt)

What is the **primary** employment status of the child's parents? (please circle one answer for each parent)

Mother	Father
1. Unemployed	1. Unemployed
2. Retired	2. Retired
3. Employed part time	3. Employed part time
4. Employed full time	4. Employed full time
5. Homemaker	5. Homemaker
6. Student	6. Student

Occupation of parents:

Mother: ____

Father____

Highest educational level of parents (please check one for each):

	Mother	Father
Elementary school	________________________	________________________
High school	________________________	________________________
Professional diploma	________________________	________________________
University degree	________________________	________________________
Graduate degree	________________________	________________________

Diagnostic Information

What is your child's "official" diagnosis?

___________ Autism

___________ PDD-NOS (Pervasive Developmental Disorder Not Otherwise Specified)

___________ Asperger's syndrome

___________ Other (describe):____

Where/by whom was your child diagnosed? _____________________________________

When was your child diagnosed? ____

Has your child been given any additional diagnoses? Yes ______ No ______

If yes, what is/are the additional diagnoses?

- ____________ Language delay
- ____________ Behaviour disorder
- ____________ Intellectual impairment/mental retardation
- ____________ Sensory integration disorder
- ____________ Attention deficit (hyperactivity) disorder (ADD/ADHD)
- ____________ Hearing impairment
- ____________ Visual impairment
- ____________ Other: ____

Who provided the additional diagnosis? ____

When did this occur? ____

Has your child been diagnosed as having any of the following medical conditions?

- ____________ Seizures
- ____________ Allergies (please specify: _________________________________)
- ____________ Sleep disorder
- ____________ Other: ____

Does your child take any prescription medications regularly? Yes ___ _ No _____

If yes, what are the names of these medications? ________________________________

Does the child/family get any help from any of the following services (either at home or in school)? (Please mark all that apply and estimate the amount of time.)

Service	Amount of time received (estimated hours per week or month, for how long [e.g., 10 hrs/week for 6 months])	Home/School?
ABA/IBI Therapy (1:1)		
Speech/Language Therapy		
Psychology Consultation		
Occupational Therapy		
Physiotherapy		
Sensory Integration Therapy		
Behaviour Consultant / Behaviour Support		
Other:		

Does your child use a weighted vest now? NO YES (please describe)

Has your child used a weighted vest in the past? NO YES (please describe)

Is there any other information you think we need to know about your child?

Thank you very much for providing this information!

Appendix F: Example data collection sheet

Observer: _______________________________ Participant:______________________________

Date: _______________ Location: ___________________ Start: __________ End:__________

Off-task behaviour: looking away from and not engaged in deliberate manipulation of materials
Sitting time: any part of buttocks on seat

Coding:
W=wandering; S=stereotypic behaviour; L=looking away; O=other

		1	2	3	4	Total
Min 1	Sitting	Y N	Y N	Y N	Y N	
	Off-task	Y N	Y N	Y N	Y N	
	Coding	W S L O	W S L O	W S L O	W S L O	
Min 2	Sitting	Y N	Y N	Y N	Y N	
	Off-task	Y N	Y N	Y N	Y N	
	Coding	W S L O	W S L O	W S L O	W S L O	
Min 3	Sitting	Y N	Y N	Y N	Y N	
	Off-task	Y N	Y N	Y N	Y N	
	Coding	W S L O	W S L O	W S L O	W S L O	
Min 4	Sitting	Y N	Y N	Y N	Y N	
	Off-task	Y N	Y N	Y N	Y N	
	Coding	W S L O	W S L O	W S L O	W S L O	
Min 5	Sitting	Y N	Y N	Y N	Y N	
	Off-task	Y N	Y N	Y N	Y N	
	Coding	W S L O	W S L O	W S L O	W S L O	

Reliability Checker: ____

Comments:

Appendix G: Investigating the feasibility of using wireless heart rate monitors to measure the effects of weighted vests on heart rate with children with autism

Introduction

Several authors have stressed the need for systematic research that investigates the efficacy of sensory-based strategies including understanding underlying neurophysiological mechanisms as well as behavioural outcomes (e.g., Baranek, 2002; Rogers & Ozonoff, 2005). One proposed method of evaluating the effects of deep pressure interventions on underlying mechanisms is through analysis of heart rate data. Changes in heart rate can indicate reactivity to specific environmental stressors, including initial reaction and one's ability to return to a steady state (Groden et al., 2005). Therefore, if weighted vests provide a calming influence, heart rate should be reduced overall and/or heart rate should return to baseline more quickly following a stressful event. The collection of heart rate data, using a rubber chest strap and a wireless transmitter, has been deemed a feasible method of assessing reactivity to specific environmental stressors in adolescents and adults with autism in a research setting (Groden et al., 2005). However, no studies are available that have looked at the feasibility of using wireless heart rate monitors with children with autism outside of research settings.

Purpose

The primary purpose of this pilot project was to investigate the feasibility of using a wireless heart rate monitor, outside of a research setting, with children with autism. Additionally, the relationship between the use of a weighted vest and heart rate was explored. Specifically, this pilot project allowed us to determine if:

1) children with autism would tolerate wearing the wireless heart rate monitor in a non-research setting;
2) if there were methodological challenges associated with using the wireless heart rate monitor; and
3) if changes in heart rate appeared to be associated with the use of weighted vests.

Methods

Participants. Participants included 8 children with autism, aged 4-10 years. The service provider through which participants were recruited required a confirmed diagnosis of autism for funding. This requirement was used to confirm diagnosis for the participants in this pilot study.

Recruitment. Children were recruited from a summer day camp program run by the service provider. A recruitment letter was sent home with all participants. Parent then contacted the researcher, who explained the study in detail. If parents were still interested in having their child participate, the researcher met the parents at the day camp to complete the screening questionnaire, or sent the screening questionnaire home with their child from day camp, to be returned with their child the next day.

Inclusion Criteria. Participants were identified by a parent as having difficulty with attention and had sensory dysfunction as evidenced by a “definite difference” score on at least one quadrant of the Sensory Profile. The Sensory Profile (Dunn, 1999) is a 125-item questionnaire, normed on more than 1000 children without disabilities, on which caregivers’ report the frequency with which their child responds to various sensory experiences. Four quadrant scores are calculated, reflecting hyper- or hypo-sensitivity and responsiveness to sensory input. A score falling in the “definite difference” range indicated a score more than two standard deviations from the mean. Internal consistency estimates (range = .47 to .91) and standard error of measurement (range 1.00 to 2.8) support instrument reliability. Dunn (1999) reports on content and construct validity (convergent, divergent), which indicate high correlations with other measures of sensory perception and behavioural regulation. Demographics were also included on the Sensory Profile.

Design. A single subject design was used. This design enabled each subject to serve as his or her own control, thereby accounting for the unique behaviours and wide variation in behavioural responses children with autism display. There were three phases to this study:

Phase 1 – Baseline: minutes 0-20
Phase 2 – Intervention: weighted vest (5% body weight); minutes 20-40
Phase 3 – Withdrawal: vest removed, minutes 40-60

Data collection. Data collection took place in a large activity room, during a variety of activities typical of day camp (e.g. songs, arts and crafts, games). It was expected that the day camp program would be anxiety provoking for some children because it involved new routines, unfamiliar staff and peers, and an unfamiliar environment. Given that weighted vests were expected to have a calming influence, it was anticipated that anxiety provoking situations might provide increased opportunity to see the potential effects of weighted vests.

Each participant wore the wireless heart rate monitor for up to one hour. If a child verbally or physically refused to wear the vest or heart monitor (e.g., cried, attempted to pull off monitor), this was documented and data collection was stopped. Monitors were donned by the researcher with the child’s parent and/or aide present, since the researcher was a stranger and the monitor went under the child’s clothing. The monitor used a rubber strap that was fastened around the child’s chest. The receiver was attached to the child’s shirt with a safety pin at the back of the child’s shoulder. The receiver recorded heart rate data in 5-second intervals.

Data analysis. Qualitative assessment of each child’s response to the wireless heart rate monitor was documented. All heart rate data was transcribed into a Microsoft Excel spreadsheet. Mean heart rate per phase, and the 95% confidence interval around the mean, were calculated for each participant. Standard deviation around the mean was calculated to investigate if the weighted vest impacted the variability of heart rate within each phase.

Results

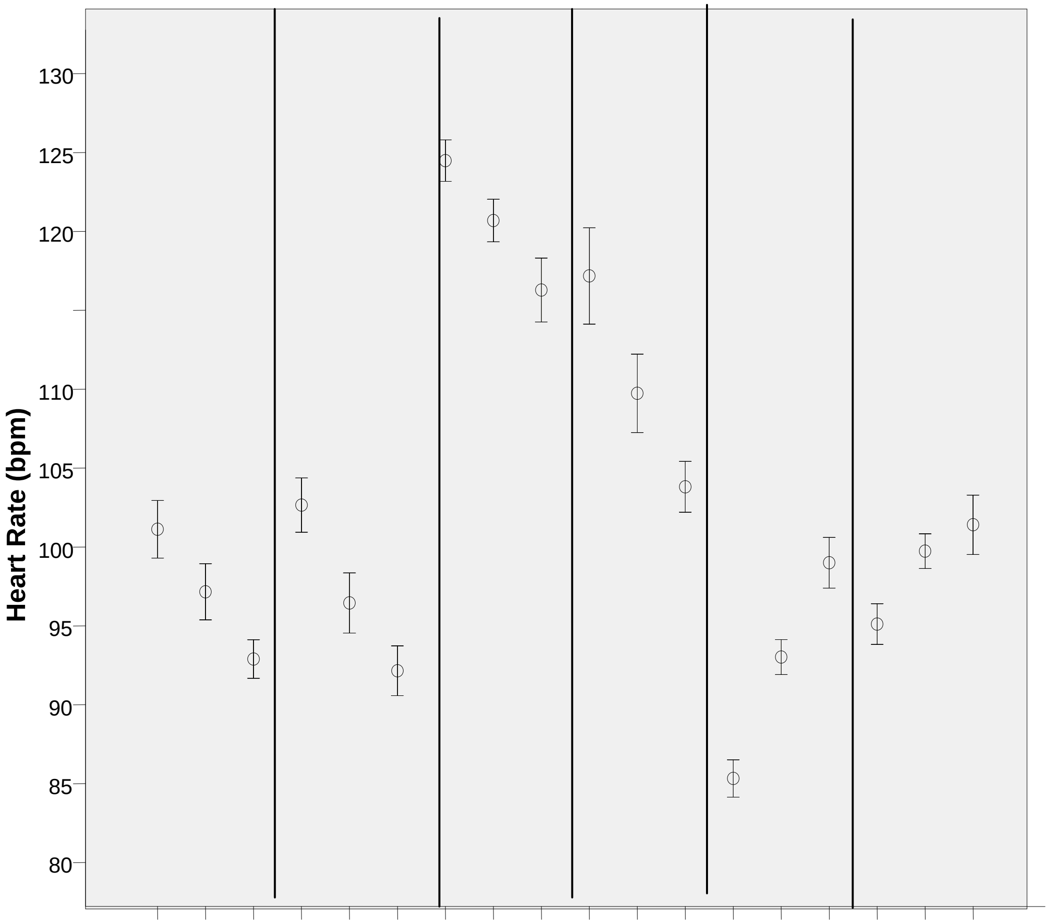
Seven of eight participants wore the wireless heart rate monitor for one hour. Four of these participants wore the monitor without any difficulties. Three participants required minor verbal (e.g., “don’t touch the monitor”) and physical (e.g., redirected hand away from shirt) prompts to keep the monitor on, but did not appear to be in any distress. One participant verbally refused the monitor upon initial presentation, so heart rate data was not collected. Heart rate data is available for only six of the seven children who wore the monitor, because the researcher did not properly start the monitor for one participant. Table 26 provides a summary of descriptive and qualitative information. Results are divided by the type of activities in which the children participated because this appeared to influence heart rate response.

Table 26. Descriptive information for feasibility study

Children		Age	Comments
Consistent activity level during data collection	1	9 yr, 9 mo	Verbal No aide required to participate in activities Very interested in heart rate monitor technology No problems wearing monitor Reported that sticky pads felt ‘hot’ at first, then did not notice
	2	7 yr, 9 mo	Non verbal Individual aide required to participate in activities Verbal and physical prompts to keep monitor on Kept touching monitor band throughout
	3	4 yr, 10 mo	Non verbal Individual aide required to participate in activities Verbal and physical prompts to keep monitor on
	4	10 yr, 0 mo	Verbal Limited aide support required to participate in activities No problems wearing monitor Said monitor “feels like a bump” when asked if it was comfortable Independently said weighted vest “slows me down, helps me focus”
Inconsistent activity during data collection	5	4 yr, 11 mo	Single word utterances Shared aide required to participate in activities No problems wearing monitor Activity level increased with phases (circle time–food prep–free play)
	6	9 yr, 3 mo	Single word utterances Shared aide required to participate in activities No problems wearing monitor Activity level increased with phases (circle time–food prep–free play)
No data	7	6 yr, 0 mo	Monitor not turned on (researcher error) Non verbal Individual aide required to participate in activities Verbal prompts to keep monitor on
	8	5 yr, 3 mo	Verbally refused to wear monitor Single word utterances, short sentences Limited aide support required to participate in activities Only female participant

Overall, heart rate data appeared to decrease with the weighted vest for four of the six participants. For these four participants, heart rate appeared to continue to decrease following removal of the weighted vest. For two participants, heart rate appeared to increase with the weighted vest and continued to increase following removal of the vest. This corresponded with the types of activities in which each child was participating: the average activity level increased with each phase of data collection. Figure 24 summarizes the mean heart rate, with the 95% confidence interval, for each participant for each phase.

Figure 24. Mean heart rate, in beats per minute (bpm), per phase for each participant.



Non-overlap between phases deemed a meaningful effect based on 95% confidence interval, represented by the bars around mean heart rate.

Discussion

Wireless heart rate monitoring appeared to be a feasible way to collect heart rate data outside of a research setting for children with autism. Based on clinical observation, the participants in this small sample who were non-verbal and who required constant aide support to participate in day camp activities likely had cognitive impairment in addition to a diagnosis of autism. All of these participants (n=3) were distracted by the monitor, requiring verbal and physical prompts to keep the heart rate monitor on. This potential distraction needs to be considered when using a device outside of a research setting: it is undesirable to distract a child from educational activities in a school setting.

There did not appear to be any other methodological challenges with using the heart rate monitor outside of a research setting. The monitors were secure on each child, and did not interfere with a child's ability to participate in any activities. Data collection, when started correctly, was complete for each child.

The weighted vest did appear to be associated with decreased heart rate in the four children for whom the activities required approximately the same level of energy expenditure across the hour. It appeared that the impact of the weight on one's nervous system was fairly immediate, and lasted beyond the removal of the weight. However, the weighted vest did not decrease heart rate in the two children for whom the activity level increased over the hour. Therefore, the weighted vest did not override the effects of activity level.

Summary

Wireless heart rate monitors appear to be a feasible tool to collect heart rate data for children with autism outside of a research setting. Methodological challenges were limited, and appeared to relate more to child characteristics than technological characteristics. Results from the pilot study provide preliminary support for the effects of weighted vests on decreasing heart rate in children with autism.

Appendix H: Social Validity Questionnaire for Teachers and Educational Aides

Child's Name: _______________________________

Questionnaire completed by: ________________________________

Date: _____________________________

Questions to be asked prior to the study:

Have you heard of weighted vests before?   YES   NO

Have you used weighted vests in your classroom before?   YES   NO

If yes, with how many children? ____________________

Did you perceive that it was beneficial?   YES   NO

If yes, was it beneficial for _____% children

In what ways was it beneficial? __________________________________

Have you used a weighted vest with this child (study participant) before?

When? _____________________

Was it beneficial?   YES   NO

If yes, in what ways was it beneficial? _____________________________

Questions to be asked following the study:

Do you think the weighted vest was beneficial for (child's name)?

If so, in what ways was it beneficial? ______________________________

Would you like to continue to use the weighted vest for (child's name)?   YES   NO

Appendix I: Treatment Fidelity Tracking Sheet

____(name)___ should wear the vest for *20 minutes each school day, at approximately the same time of day, even on days when the researchers are not collecting data* during _____(activity)_____ .

We realize that there may be days when he does not wear the vest. For example, he may be absent or refuse to wear the vest. Please track the child's participation below with a ✓ for each day the child wore the vest, and a comment, for each day the child did not wear their vest (e.g., absent). There is also room to write additional comments.

Please follow these directions carefully. Contact Sandy Hodgetts with any questions, problems or issues that come up during the study (sandra.hodgetts@ualberta.ca; 492-8568).

The only materials you will need are the child's vest, and the weight or fake weight packets. The packets must be in the vest prior to the researchers' arrival. It is very important that the researchers and the teacher do not know if the vest is weighted or unweighted. Please keep the extra packets in their container so they are out of view. If you need information about which phase you are in (weights or fake weight), contact Joyce Magill-Evans at joyce.magill-evans@ualberta.ca or 492-0402.

When putting on the child's vest, please use this as a guide (you may paraphrase):
"It's time to put your vest on. We are going to keep it on for 20 minutes".
Removing vest: *"We are going to take off your vest now".*

Week	Dates	Monday	Tuesday	Wednesday	Thursday	Friday
Example	January 7-11	✓	✓	Away	✓	✓
1	Jan 30-Feb 1	Desensitize	→			
2	Feb 4-8					
3	Feb 11-15					
4	Feb 18-22	Family Day				
5	Feb 25-29					
6	March 3-7					
7	March 10-14					
8	March 17-21					Good Friday
9	March 24-28	Easter Monday				

Additional Comments: