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VESTIBULAR FUNCTION AND POSTURAL CONTROL IN CHILDREN RECEIVING INTERVENTION WITH THE ASTRONAUT TRAINING PROTOCOL

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A dissertation submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in fulfilment of the requirements for the degree of Master of Science in Occupational Therapy.

Johannesburg,

2019

Declaration

I, Gabrielle Tova Katzenellenbogen, declare that this research report is my own work. It is being submitted for the degree of Masters of Science in Occupational Therapy at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.



_____

(Signature of candidate)

On this 10th day of June 2019 in Johannesburg

Abstract

The vestibular system plays an important role in postural control and an upright posture at the table. Some children have difficulty in their in-seat posture resulting in increased in-seat movement. This research investigated the effect of the Astronaut Training Protocol on a child's vestibular processing and postural control, and therefore by extension their in-seat behaviour, as well as whether there would be carry over after the protocol was terminated.

A single subject quasi experimental ABA research design was used with five participants who were identified with dysfunction in in-seat posture and in-seat movement. Data was collected over three phases: pre-Astronaut Training (A), post-Astronaut Training (B), and Withdrawal phase (A). The Pre Astronaut Training phase consisted of four sessions of sensory integration based occupational therapy, with the Intervention phase following consisting of eight Astronaut Training sessions during which regular sensory integration occupational therapy remained constant, while the Withdrawal phase comprised of four sessions of regular sensory integration based occupational therapy.

Four assessments were used to determine vestibular and postural control change at each phase: Movement ABC one-leg balance, Postrotary Nystagmus (PRN) test, in-seat posture assessment (designed for the purpose of this study), and in-seat movement through the collection of data using an accelerometer. Repeated measures of the prone extension and supine flexion positions were used at each therapy session to measure both vestibular processing and postural control.

Improvements in postural control and vestibular function were seen in prone extension and supine flexion quality and time for most participants post-Astronaut Training (B). A large effect size indicating a clinical change for in-seat posture and in-seat movement was found post-Astronaut Training (B), indicating improved posture with less fidgeting at the table. Vestibular improvements were seen at Withdrawal phase (A) for balance and PRN with a medium effect size on balance and large effect size for PRN. Participants' in-seat posture and in-seat movement did not continue to improve and deteriorated slightly in this phase although this differed depending on their responsivity to PRN and diagnosis.

This research showed that the intervention with the Astronaut Training Protocol can improve vestibular function and postural control in children with poor in-seat posture and in-seat movement, although the frequency and intensity of the programme still need to be confirmed.

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Definition of Terms

Ayres sensory integration: Sensory integration therapy that stimulates the sensory systems in accordance with the child's neurological needs. The therapist is required to adhere to 10 fidelity criteria to facilitate an adaptive response (Ayers, 1982; Parham, et al., 2011).

Postural control: "Involves controlling the body's position in space for the dual purpose of stability and orientation" (Shumway-Cook & Woollacott, 2012, p. 162).

Proprioception: The sensation from the muscle and joint receptors which assists in interpreting rate, timing and force needed for the muscles to exert as well as where the body is in space. (Lane, 2002).

In-seat behaviour: The behaviour exhibited whilst seated for tabletop tasks, comprising of in-seat movement and in-seat posture.

In-seat movement: Movement or fidgeting whilst seated in a chair for table-top tasks.

In-seat posture: The use of upright posture whilst sitting on a chair for table-top tasks.

Postrotary nystagmus: "Involuntary rhythmic movements of the eye following short (20 second duration) rotation. It consists of rapid movements of the eye in one direction followed by a slow movement in the opposite direction. In postrotary nystagmus, the fast component is in a direction opposite that of the spin." (Bundy, et al., 2002, p. 479).

Sensory integration: "The neurological process that organises sensation from one's own body and from the environment and makes it possible to use the body effectively within the environment; the entire sequence of central nervous system events from reception to the display of an adaptive environmental interaction." (Bundy, et al., 2002, p. 479)

Sensory integration based therapy: "A programme of intervention involving meaningful therapeutic activities characterised by enhanced sensation, especially tactile, vestibular, and proprioceptive, active participation and adaptive interaction." (Bundy, et al., 2002, p. 479)

Vestibular system: The vestibular system is situated in the inner ear and comprises of the otolith organs and semi-circular canals. It responds to the movement of the head-rotations, inversion and acceleration. It assists in posture, maintaining a stable visual field, eye movements, balance and autonomic nervous system functions (Hardy & Dyer, 2013; Lane, 2002; Mailloux, et al., 2014).

Abbreviations

ADHD - Attention Deficit Hyperactivity Disorder

ASI®- Ayres Sensory Integration

AT- Astronaut Training

Movement ABC-2 - Movement Assessment Battery for Children 2

PE - prone extension

PRN - postrotary nystagmus

SF - supine flexion

VOR - Vestibular-Ocular Reflex

CHAPTER 1: INTRODUCTION

1.1 Introduction to the study

Over a number of years, an infant develops conscious control of complex postural reactions which support the ability to maintain body positions against gravity. This allows the child to achieve developmental milestones such as sitting, crawling and walking from an early age. These postural reactions are dependent on foundations laid by the primitive reflexes present in the first few months of life which support the complete development of postural reactions and automatic postural adjustments to counteract gravity (Fiorentino, 1981). These reactions and adjustments develop from the integration of the vestibular system. The vestibular system is fully functional at birth and is refined through movement experiences such as being held in different positions, rocked and actively moving against gravity when reaching developmental milestones (Parham & Mailloux, 2005).

The vestibular system is responsible for maintaining the head in midline, upright body posture, postural control, balance, and providing a stable visual field. It consists of the semi-circular canals and the otolith organs situated in the inner ear. The visual, auditory and somatosensory systems are closely linked to the vestibular system, and the systems impact on each other (Bundy, 2002). The vestibular system influences, via the basal ganglia, cerebellum, and vestibulospinal tracts, the maintenance of upright posture, the alteration of muscle tone and the control of postural and equilibrium reactions (Ayres, 1982).

Developmental delays in vestibular processing, therefore impact negatively on a number of factors including poorly integrated primitive reflexes, poor postural control and low postural tone (Reeves & Cermak, 2002). In order to succeed in the classroom, children need to maintain an adequate upright posture in sitting at a desk while performing academic tasks. Low postural tone and a lack of adequate postural control may result in an inability to maintain this posture. Children with these deficits tend to flex over the desk and use their non-dominant hand to prop up their head while working

on school-related tasks (De Jager, 2009; Hanscom, 2016). They may seek additional sensory input such as proprioceptive and vestibular input by moving in their seats (Pfeiffer, et al., 2008). This movement facilitates their postural control but compromises their ability to pay attention in class. The conscious effort required to monitor and maintain their posture as well as the fatigue experienced further compromises the mental energy needed for learning (De Jager, 2009). Therefore, children with poor vestibular processing display decreased balance, poor posture, a lack of attention and tend to move or fidget in their seats constantly (Pfeiffer, et al., 2008).

When treating vestibular dysfunction, occupational therapists use a sensory integration framework which was developed by A. Jean Ayres. Sensory integration is the neurological process of organising sensation from the body and making it possible to adapt and use the body effectively in the environment. Sensory integrative based therapy focuses on the active participation of the child whilst enhancing sensation from the tactile, vestibular and proprioception systems (Bundy, 2002). Ayres proposed that the vestibular system is the key to sensory integration with all other sensory systems superimposed upon the input of the vestibular system (Ayres, 1982).

Therefore, the interaction of the vestibular, visual, auditory and somatosensory systems is important, and when this is not functional, sensory information received may be interpreted in a fragmented way. In addressing dysfunction in the vestibular system and the linked sensory systems, appropriate oculomotor skills, body awareness, muscle tone, posture, bilateral integration and praxis are able to be facilitated (Frick & Young, 2012). The Astronaut Training Protocol was designed, based on a sensory integration framework, to stimulate and integrate the vestibular, visual and auditory systems (Kawar, et al., 2005).

1.2 Statement of the problem

A number of referrals to occupational therapy are from teachers of children who have difficulty keeping an upright posture and display excessive in-seat movement (Hanscom, 2016). Teachers often find fidgeting disruptive as it leads to inattention in

the classroom. According to Hanscom (2016), over the past five years, occupational therapy referrals have increased by 20 to 30% in three cities in the United States of America. Teachers are finding that they have to adapt their teaching methods by teaching in smaller groups due to increased fidgeting and difficulty paying attention in the classroom. Children frequently make excuses to get out of their desks during lessons, instead of sitting quietly and paying attention. Hanscom states that some of the reasons children cannot sit still are due to the increased time spent on electronic devices, fear of children getting hurt on playgrounds, and parents' concerns around crime. This results in static play time instead of physical child-directed activity which is needed to stimulate the vestibular system.

There is a need for evidence-based research to justify why occupational therapists use certain intervention programmes. Literature provides evidence regarding the role of the vestibular system in developing muscle tone, postural adjustments and postural control which is needed for adequate sitting posture. An intervention programme called the Astronaut Training Protocol was designed to stimulate the vestibular, auditory and visual systems. To date, there is no research on the effectiveness of this programme. This paper will, therefore, consider the effect the Astronaut Training Protocol has on stimulating the vestibular system in terms of postural control of in-seat posture and in-seat movement.

1.3 Purpose of the study

The purpose of the study was to determine what effect stimulating the vestibular system through the use of the Astronaut Training Protocol would have on the vestibular function of children. The effects were measured in terms of balance and Postrotary Nystagmus as well as in-seat behaviour (posture and movement) related to postural control during table-top activity.

Vestibular function and postural control were monitored by the participant's ability to assume and maintain postures which reflected the integrity of the vestibular system-prone extension and supine flexion.

1.4 Research question

Does the implementation of the Astronaut Training Protocol have an effect on vestibular function, posture and in-seat movement in children with poor in-seat behaviour?

1.5 Aims and objectives

1.5.1 Aim

To determine if the Astronaut Training Protocol has an effect on vestibular function and postural control in children with poor in-seat behaviour.

1.5.2 Objectives

- To determine the vestibular function and postural control related to Postrotary Nystagmus (PRN), balance, in-seat posture and in-seat movement, and the postures of prone extension and of supine flexion in children with poor in-seat behaviour (posture and movement).
- To determine the change in vestibular function and postural control related to Postrotary Nystagmus (PRN), balance, in-seat posture and in-seat movement, and the postures of prone extension and of supine flexion in children when they receive intervention using the Astronaut Training Protocol.
- To determine if a change in vestibular function and postural control is maintained after withdrawal of the Astronaut Training Protocol.

1.6 Null hypothesis

No change in the vestibular processing relating to postural control and in-seat behaviour will be seen when children do and do not receive intervention using the Astronaut Training Protocol.

1.7 Justification for the study

As stated, little research has been done on the effectiveness of the Astronaut Training Protocol. If research evidence can be provided by this study suggests it is effective, the use of the programme in occupational therapy can be justified. Implementation of the protocol has the potential to offer an alternate method of therapy for vestibular processing dysfunction in children to improve their vestibular function and postural control. This will be assessed in terms of their in-seat behaviour, which if it improves, may result in improved performance in the classroom.

CHAPTER 2: LITERATURE REVIEW

2.1 Introduction

Children are not receiving sufficient movement due to the increase in the development of technology and time spent on screens (Clements, 2004) as well as the increase in time spent sitting during structured activities in the classroom (Hanscom, 2016). According to Bassok, et al. (2016) there is more pressure on teachers to get children academically ready for Grade 1, thus preschool and Grade R classrooms spend less time on free play and exploration, with more emphasis on academically orientated activities and table-top tasks. Deterioration in children's posture and the increased need to fidget has therefore been observed, as well as an increase in developmental disabilities such as attention deficit hyperactivity disorder. From the researcher's discussions with teachers, it has been noted that teachers have noticed that more students are struggling to sit and pay attention and are constantly fidgeting or getting out of their chairs. Hanscom (2016) explains that this is due to the decreased time children spend moving and engaged in physical play, resulting in them not developing sufficient core muscle strength to keep themselves sitting upright during the classroom.

This chapter will cover the importance of an upright posture of children in the classroom. The underlying components of postural control with the focus on the vestibular system will be investigated. The assessment of postural control based on the literature and the various interventions, specifically the Astronaut Training Protocol in occupational therapy related to paediatrics, will be examined. Literature from the 1980s and 1990s, during which some iconic studies on the vestibular system and vestibular processing were published, has been considered and reported on where appropriate. Information was sourced from non-academic sources due to the lack of information in academic references in relation to fidgeting in the classroom. The information has been sourced from textbooks and databases such as ScienceDirect, ERIC, EBSCO Host and Pubmed. Keywords included "vestibular system", "proprioception" and "postural control in the classroom".

2.2 Postural control

To succeed in a classroom, a child needs to be able to maintain an upright posture whilst seated at a desk during academic tasks. Traditional schools see fidgeting and restlessness as unacceptable behaviour and disruptive to the teacher (Domljan, et al., 2010). Low postural tone and poor postural control may result in the child being flexed over the desk, seeking in-seat movement or propping his/her head or trunk up for support. This may lead to fatigue and more energy expended on keeping the upright position as opposed to focusing on learning. The child may hold onto the chair or desk to maintain the body in an upright position or may flex over the desk, using the non-dominant hand to prop up the head while working on school-related tasks (Blanche, et al., 1995). This negatively impacts on the development of fine motor skills such as handwriting as the hands and arms are not free to move (Amundson, 2005; Blanche, et al., 1995). Reduced proximal stability may also be observed which can impact on pencil control and fine motor skills (Wang, et al., 2011). Grade R is the first formal school year and children are required to follow instructions, attend to the teacher and sit with an upright posture (Department of Basic Education, 2011). A large portion of the school day is spent seated at a desk (Amundson, 2005).

Postural control is the ability to sustain alignment of the body whilst upright in space. It requires the development of muscle strength for anti-gravity movements, proximal axial control, dynamic co-contraction and mature postural reactions (Nichols, 2005). To achieve postural control and upright posture, the integration of the vestibular, somatosensory and visual systems is needed (Nichols, 2005) as well as the musculoskeletal systems (Shumway-Cook & Woollacott, 2012). Studies have shown that these sensory systems have a direct impact on unconscious postural sway and the maintenance of the body positions against gravity (Hansson, et al., 2010; Vuillerme & Nougier, 2004).

Ayres discusses these automatic adjustments, which if underdeveloped, can result in a child not being able to adjust his/her body appropriately affecting the ability to perform everyday activities (Ayres, 1978). In the classroom, a child may struggle to adjust their posture after picking up an object off the floor or may have reduced co-

contraction and proximal control needed to maintain an upright position at the table. Therefore, the child may slouch or fidget to activate certain muscles to compensate. In this paper, postural control will be analysed in relation to in-seat posture and in-seat movement.

2.2.1 The different approaches to postural control

Postural control and motor development of a child are directly linked. A child needs to have adequate postural control to achieve their developmental milestones. The motor control and dynamic systems theory are used to explain motor development. Factors such as body mass, muscle strength, sensory processing, behaviour, cognition and interacting with the environment all impact a child's development of postural control (Nichols, 2005).

Antigravity movements develop through the stages of mobility, stability, proximal muscle co-contraction, mobility superimposed on stability and then the development of the skill (Stockmeyer, 1969). Postural reactions develop in prone, supine, sitting, four-point kneeling and then standing (Nichols, 2005). Righting reactions, equilibrium reactions, protective extension and Landau reflex all contribute to the development of postural control. The way the child experiences the environment and practices these movements has an impact on how their postural control develops. Anticipatory postural control develops from the experience of movement and relies on the feedforward mechanism so that the child can anticipate the reaction before movement takes place (Nichols, 2005; Shumway-Cook & Woollacott, 2012).

The integration of the sensory systems plays a role in the development of postural control (Nichols, 2005). The visual, vestibular and somatosensory systems are an important foundation for the development of postural control and the orientation of the body in space (Nichols, 2005; Shumway-Cook & Woollacott, 2012). Feedback control is required from the sensory systems to adjust a body position during the task (Shumway-Cook & Woollacott, 2012). If these systems are not fully integrated, a child may have slow postural adjustments, move stiffly, have poor balance and may use

compensatory techniques resulting in more effort and fatigue (Ayres, 1982). It is therefore important to analyse the sensory systems, especially the vestibular system and their contribution to the development of postural control.

2.3 Vestibular system

The vestibular system is situated in the inner ear and consists of the semi-circular canals and the otolith organ. It supports several important functions related to balance, postural control, and mobility including balance reactions, the upright positioning of the head in relation to gravity, maintaining a stable visual field, eye movements, postural adjustments, bilateral coordination and autonomic nervous system functions (Hardy & Dyer, 2013; Lane, 2002; Mailloux, et al., 2014). These functions are required to successfully perform daily life activities (Mulligan, 2011) and children require an intact vestibular system to develop sufficient gross motor and fine motor skills which facilitate their appropriate interaction and participation in the classroom (Mailloux, et al., 2014).

The vestibular system is a complex system linking many of the other sensory systems such as the auditory, visual and proprioceptive systems and has been described as the primary organiser of all our sensory information (Lane, 2002). It is therefore important to understand these connections as the systems cannot be seen in isolation due to their neural and functional integration. Ayres (1982) proposes that the vestibular system is the key to sensory integration with all other sensory systems superimposed upon the input of the vestibular system.

2.3.1 Effect of vestibular dysfunction on postural control in the classroom

Children who display difficulties processing input from the vestibular system may have trouble in determining the spatial orientation of the head and may, therefore, struggle to keep the head and body in the upright position whilst seated in the classroom. Poor vestibular processing in the otolith organs can result in a lack of registration of the

upright position of the head required for adequate visual input in the classroom. Poor processing of the receptors in the semi-circular canals results in an inappropriate response to movement as well as the integration of eye movements (Lane, 2002). These are important in the classroom as children need to be able to turn their heads to sounds, to look at the teacher, as well as to copy from the blackboard (Kawar, et al., 2005).

Children with poor vestibular processing who display decreased balance and poor posture may seek additional sensory input such as proprioceptive and vestibular input by constantly moving or fidgeting in their seats (Pfeiffer, et al., 2008). This movement facilitates their postural control but compromises their ability to pay attention in class due to the conscious effort required to monitor and maintain their posture. The fatigue experienced further compromises the mental energy needed for learning (De Jager, 2009). According to Pfeiffer, et al. (2008), children with poor vestibular processing display decreased balance, poor posture and attention, and constantly move or fidget in their seats. Fidgeting is a compensatory strategy for children in an attempt to gain more sensory input to feel alert enough to focus, however, often this movement does not provide enough intensity to sustain the focus required (Hanscom, 2016).

Children with neurologic pathology find it difficult to maintain balance and postural control whilst performing multiple tasks (Shumway-Cook & Woollacott, 2012) required in the classroom. Difficulty doing both these tasks can be equated to dual-task performance (Shumway-Cook & Woollacott, 2012). During dual performance tasks, a child will usually prioritise and perform better in one of the tasks so either there will be a decrease in cognitive performance, or balance and posture will deteriorate (Shumway-Cook & Woollacott, 2010). According to Laufer, et al. (2008), children with Developmental Coordination Disorder (DCD) displayed more postural sway and instability during a cognitively demanding task than neuro-typical children.

Although most of the research on postural control in dual-task performance has been completed in the standing position, researchers believe this to be equally true in the seated position (Shumway-Cook & Woollacott, 2012). These theories indicate that posture may deteriorate as the cognitive complexity of tasks increases in the

classroom. This was evident during the single subject design on children with Autistic Spectrum Disorder in the research of Bagatell, et al. (2010), where children with reduced postural control struggled to engage in activities in the classroom when their postural stability was compromised by sitting on a therapy ball.

This paper will, therefore, determine the effect the stimulation of the vestibular system has on a child's postural control at the table (in terms of in-seat posture and in-seat movement) and whether their posture improves with this input. The structure and function of the vestibular system will, therefore, need to be examined.

2.3.2 Structure and function of the vestibular system

The receptors for the vestibular system located in the vestibular apparatus consist of the otolith organs and the semi-circular canals. These receptors monitor the effect of gravity on the body as well as sensory information related to motion, equilibrium, and spatial orientation (Angelaki D, 2008; Hardy & Dyer, 2013). They contain hair cells called stereocilia which become depolarised or hyperpolarised with movement, resulting in the opening of potassium channels (See Figure 2.1).

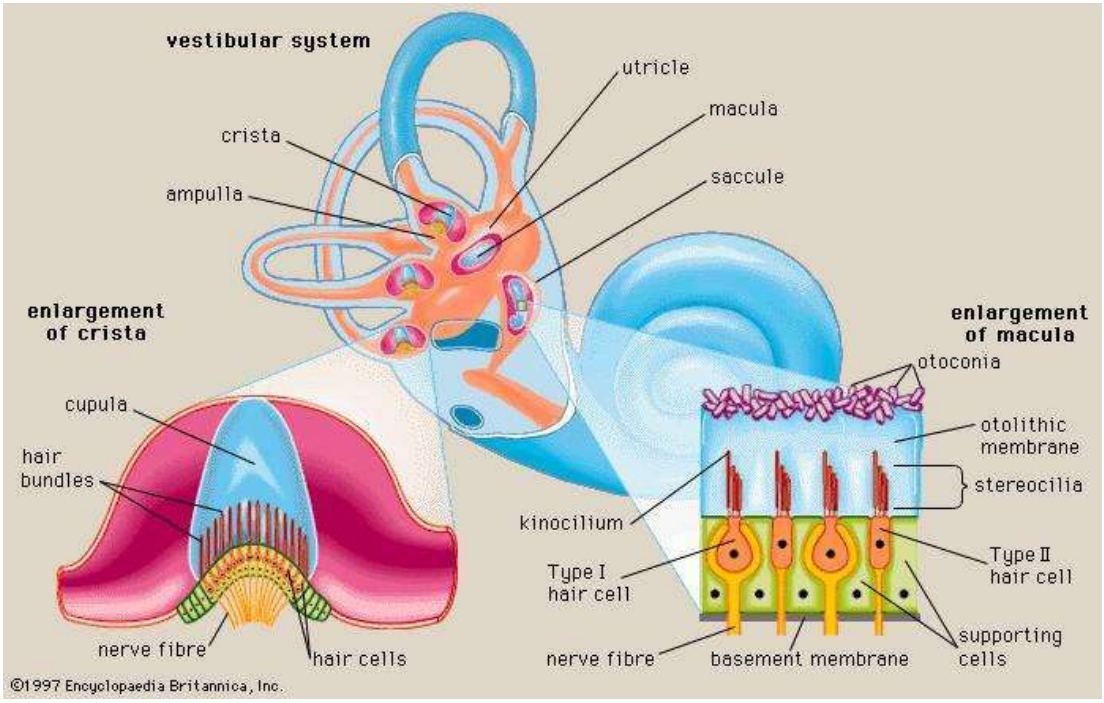


Figure 2.1 The vestibular system contains the semi-circular canals and otolith organs (utricle and saccule). (Encyclopaedia of Britannica, 1997) www.britannica.com/science/vestibular-system

The otolith organs

The slow adapting otolith organs (utricle and saccule) are located at the base of the semi-circular canals and continuously sense the pull of gravity (Angelaki D, 2008). They are sack-like organs positioned in the vertical and horizontal planes (Lane, 2002) which respond to linear input, head position, and low-frequency stimuli. Their main function is to assist in maintaining the upright vertical position of the head and posture as well as facilitating balance (Hardy & Dyer, 2013; Lane, 2002). The utricle is positioned in the horizontal plane and responds to linear and sustained movement as well as low-frequency stimuli. The saccule detects vertical movement and anterior and posterior movements (Hardy & Dyer, 2013; Lane, 2002).

The function of the otolith organs is based on their structure and neural connections. Inside the utricle and saccule is the macula which consists of hair cells and suspended

above these cells in a gelatinous material are the otoconia made up of calcium carbonate crystals. When the head tilts there is displacement of the otoconia which creates a synapse with the hair cells and activates the vestibular ganglion (Lane, 2002). At rest, the otolith organs are constantly being stimulated due to their greater density than the surrounding endolymph (Lane, 2002). The otolith organs will ensure that a child is able to maintain balance and keep the head and posture in the upright position whilst sitting in the classroom (See Figure 2.2).

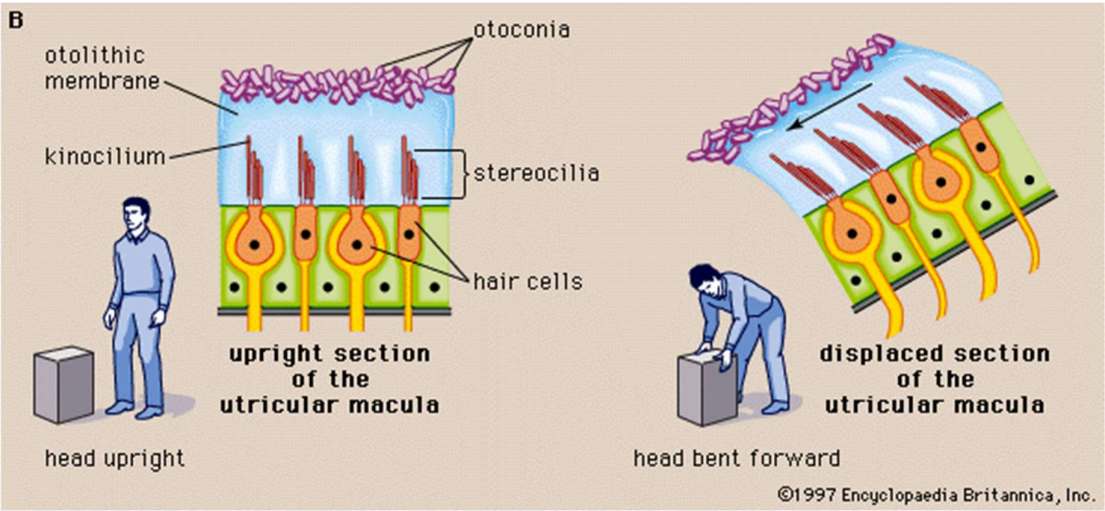


Figure 2.2 Structure and function of the otolith organs (Encyclopaedia Britannica, 1997) https://www.britannica.com/science/macula

The semi-circular canals

The semi-circular canals consist of three closed tubes, containing endolymph, positioned at right angles to each other and respond to angular acceleration and deceleration (Lane, 2002). Each tube has a dilated ending called the ampulla which houses the hair cells in a gelatinous material embedded in a cupula. The endolymph in the canals is stimulated when the head moves in a rotatory pattern and causes the cupula to lag behind the movement due to inertia. This causes the cupula to be displaced which activates the vestibular nerve. With continuous rotation, the cupula returns to the resting position and therefore there is no further distortion of the cupula.

With the cessation of movement, the cupula is again stimulated via inertia and the vestibular nerve is activated once again (Hardy & Dyer, 2013; Lane, 2002). In the classroom, the semi-circular canals are stimulated when a child turns his/her head as seen when copying from a book or blackboard, as well as watching the teacher or classmates move around the room (See Figure 2.3).

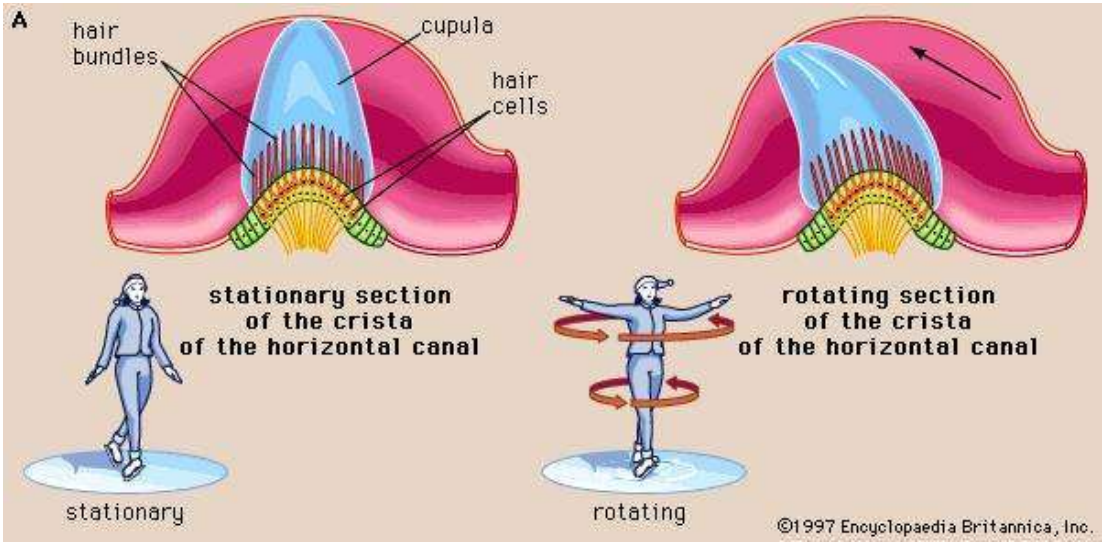


Figure 2.3 Structure and function of the semi-circular canals during rotary movement. (Encyclopaedia of Britannica, 1997) https://www.britannica.com/science/ear/images-videos/media/175622/138568

2.3.3 Effects of vestibular dysfunction on postural control

The vestibular system is fully functional at birth (Jamon, 2014) and is refined through movement experiences when reaching developmental milestones (Nichols, 2005). The ability to maintain an upright posture against gravity is an automatic response dependent on subtle adjustments that are made in responses to the supporting surface. Over the years, an infant develops conscious control of complex postural reactions which support the ability to maintain body positions against gravity (Nichols, 2005). This allows the child to achieve developmental milestones such as sitting and walking from an early age. These postural reactions are dependent on foundations laid by the primitive reflexes present in the first few months of life which support the

complete development of postural reactions and automatic postural adjustments to counteract gravity during mobility and stability (De Jager, 2009; Fiorentino, 1981). When postural control develops normally, a child can sit at a desk with an upright posture leaving the hands free for academic tasks, with the head being at an optimal position for visual contact with the classroom environment (Boehme, 1990).

2.4. Integration of the vestibular, proprioceptive, visual and tactile systems

The vestibular system contributes to a number of reflex pathways involved in compensatory movements and adjustments in body position as well as pathways that project to the cortex linking with the proprioceptive, auditory, visual and tactile systems (Lane, 2002). The structure and function of the links between these systems are summarised in Figure 2.4.

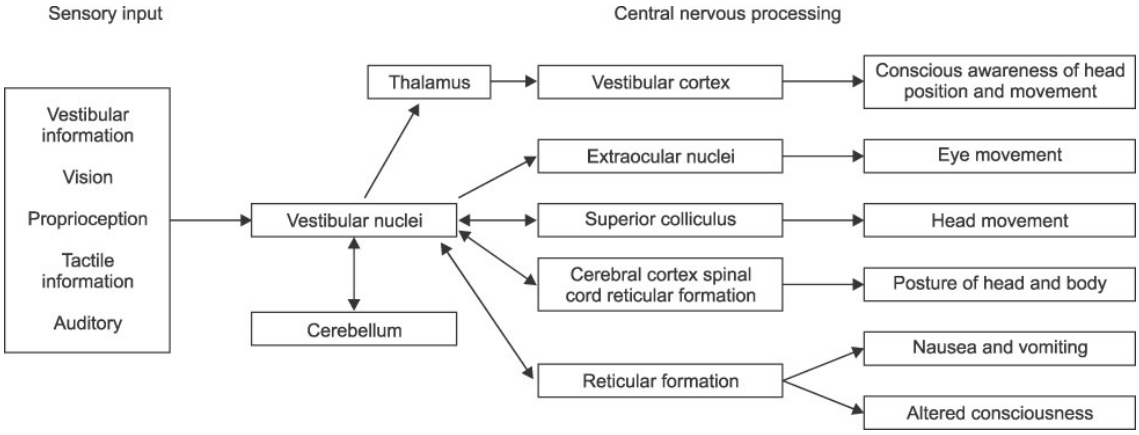


Figure 2.4 Integration of the vestibular, proprioceptive, auditory, visual and tactile systems (Im, 2013)

2.4.1 Vestibular and somatosensory systems

The somatosensory system comprises of the tactile and proprioceptive systems (Lane, 2002). The tactile system is the first system to function in utero and assists in a child's experience of the world (Lane, 2002). Tactile receptors are called mechanoreceptors and respond to light touch, deep pressure, stretch and vibration (Lane, 2002). Proprioceptors arise from muscle spindles, ligaments, muscles, tendons and mechanoreceptors from the skin (Blanche, et al., 2012). Their function is to provide a sense of body awareness (Lane, 2002) and motor control as well as impacting on behaviour regulation (Blanche, et al., 2012).

Somatosensory input is transmitted via two pathways to the central nervous system: The Dorsal Column Medial Lemeniscal Pathway (DCML) and the Anterolateral Pathway (AL). The DCML transmits vibration, touch-pressure and proprioceptive information and modulates arousal by having a calming effect on the sensory system when stimulated. The AL pathway transmits pain, crude touch and temperature and has an arousing effect on the sensory system by stimulating the autonomic nervous system. Together they assist in our protection and survival as well as in discrimination of the interpretation of tactile-proprioceptive input (Lane, 2002).

Proprioceptive input is also mechanical and the input from all these receptors is transmitted to the brain via the Dorsal Column Medial Lemeniscal Pathway (DCML). The transmission of information regarding body and limb position is therefore dependent on the intact functioning of the DCML (Lane, 2002). Input through this track interacts with the vestibular system to assist in providing the body awareness of the position of the body in space (Lane, 2002).

Proprioception is linked to vestibular processing (Blanche, et al., 2012) and together with the vestibular system provides information about where the body is in space which assists with interacting with the environment. The interactions between these two systems can be seen in the vestibulocollic and vestibulospinal reflex - these are reflexive neck and body movements which arise from vestibular and proprioceptive input. Vestibulocollic reflex stabilises the neck with body movement (Goldberg &

Cullen, 2014), whereas the vestibulospinal reflex allows for postural stability so as to prevent falling which is also known as “righting reactions” (Hain, 2014).

2.4.2 Vestibular and visual systems

The vestibular system has a direct connection with the muscles of the eyes and thus impacts on eye movements (Lane, 2002). The vestibular ocular reflex (VOR) results in compensatory eye movements through the interaction of the visual and vestibular systems so that the eyes maintain a stable visual field during head movement (Mailloux, et al., 2014). When the head is stationary the eyes remain stationary, however, with head movement, the vestibular ocular reflex is stimulated and the eyes reflexively move in the opposite direction of the head, so the image seen is stable (Hardy & Dyer, 2013; Lane, 2002). If these systems do not work together, vision can become blurry with movement (See Figure 2.5).

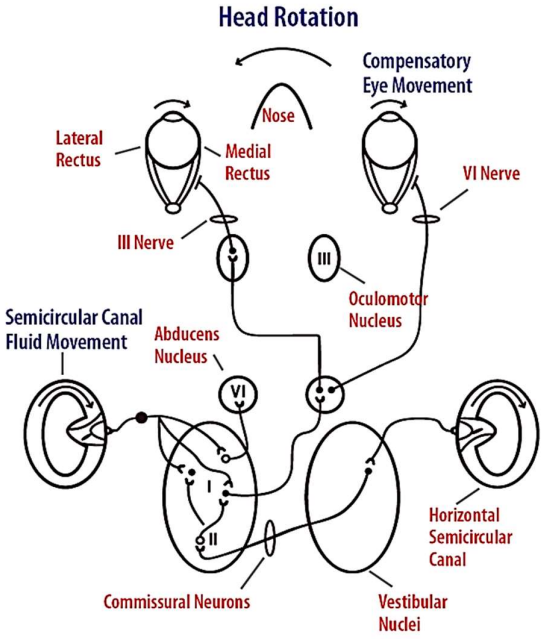


Figure 2.5 Interaction of the vestibular and visual systems- the vestibular ocular reflex (Angelaki D, 2008)

Another reflexive eye movement which is due to rotary vestibular stimulation is nystagmus. With body rotation, nystagmus in the eyes is seen. The nystagmus has a slow phase and a quick phase which is reflected in fast rhythmic oscillation movement of the eyes in the opposite direction to the rotation (Fisher, et al., 1986; Servello, 1981). The presence of postrotary nystagmus once the body has stopped rotating results in a feeling of dizziness and is as if the environment is moving due to the eye muscles being stimulated after rotation. The impulses from the vestibular system can last several seconds after the head has stopped moving (Lane, 2002). The direction of nystagmus depends on which semi-circular canal is being stimulated. The horizontal canal results in horizontal nystagmus, posterior canal in torsion (rotary) nystagmus (Parnes, et al., 2003) and anterior canal in vertical nystagmus (Kawar, et al., 2005).

Nerve impulses from the semi-circular canals synapse on the medial vestibular nuclei and via the medial longitudinal fasciculus impulses travel to the oculo-motor (III), trochlear (IV) and abducens nerves (VI) which have an impact on the eye movements (Hardy & Dyer, 2013). The medial and superior vestibular nuclei impact eye muscle movement coordinating the eye, head and body movement. This interaction between the vestibular and visual system also plays a role in coordinating movements of the head in space, postural tone and equilibrium reactions (Lane, 2002).

Therefore, smooth eye movements can be linked to intact processing of the semi-circular canals (Lane, 2002). A stable posture and head control are needed for visual tracking (Kawar, et al., 2005). Children need to have a stable neck and trunk in order to have adequate eye movements and also need to be able to keep a stable visual field when the body or head is moving. Difficulties in visual tracking can impact copying from the blackboard, reading and writing (Kawar, et al., 2005).

2.4.3 Structural connectivity of the vestibular system with the visual, tactile and proprioceptive systems

The lateral vestibulospinal tract (LVST) receives input from the otoliths, semi-circular canals, vestibulo-cerebellum and spinal cord. These projections innervate the muscles

of the spinal cord at the cervical, lumbar and sacral levels, thus having an impact on the anti-gravity muscles and the ability to maintain an upright posture against gravity and balance (Lane, 2002; Shumway-Cook & Woollacott, 2012).

The four vestibular nuclei also influence muscle tone via the LVST and the medial vestibulospinal tract (MVST). This facilitates the postural extensor muscles and inhibits the flexors. Interactions with the proprioceptive systems also contribute to the sense of body awareness, postural response, equilibrium reactions and extensor muscle tone (Lane, 2002).

The MVST receives projections from the cerebellum, skin and joint proprioceptors which project to the flexors and extensors muscles of the cervical spinal cord, thus assisting in maintaining the upright position of the head in space against gravity (Lane, 2002), as well as a stable gaze during head movement (Shumway-Cook & Woollacott, 2010).

Therefore, positions which require sustained contraction of anti-gravity muscles (Rine & Wiener-Vacher, 2013) such as prone extension and supine flexion can be used to determine the integration of the integrity of the vestibular system and postural control (Montgomery, 1985). The prone extension position assesses the control of the back extensor muscles in the prone position while the supine flexion position assesses the ability to overcome the facilitation of postural extension (Fanchiang, 1989) and assume neck flexion (Bundy, 2002). Both positions have been shown to have a significant association to the quality of postural control and dynamic balance in young children, further confirming the interaction of all these components in relation to vestibular function (Montgomery, 1985).

The reticular formation receives input from all the sensory systems, and it runs through the brainstem. Its function is to regulate arousal and consciousness. Information from the vestibular system comes to the reticular formation via the inferior vestibular nucleus (Shumway-Cook & Woollacott, 2010). If a child has difficulty modulating vestibular input from the semi-circular canals, they may have an intolerance to movement, feel

nauseous or vomit. This can also have an impact on their emotional wellbeing (Lane, 2002).

2.5 Assessment of the vestibular system, vestibular processing and postural control

2.5.1 Assessment of the vestibular system and vestibular processing

There is a limited number of standardised assessments available for evaluating vestibular function in children. Therapists use clinical observations and assessments of movement and gross motor performance to infer vestibular processing. Antigravity postures, such as a prone extension and supine flexion posture can be observed (Wilson, et al., 2000) and the balance subtests from other gross motor assessments provide information about vestibular processing. The balance subtests in the Bruininks-Oseretsky Test of Motor Proficiency-2 (Bruininks & Bruininks, 2005) and Movement Assessment Battery for Children-2 (Henderson, et al., 2007) may be used to provide information about postural control and balance, although it must be recognised that they were not designed to assess vestibular function (Mulligan, 2011). A tilt board may also be used to assess protective extension (Nichols, 2005), postural adjustments, balance and righting and equilibrium reactions (Bundy, 2002; Steindl, et al., 2006). Reflexes can also be assessed to determine vestibular processing (Nichols, 2005). Postural background movements, proximal joint stability and extensor muscle tone can also be observed to determine a vestibular dysfunction (Bundy, 2002).

The assessments which have a direct impact with the vestibular system such as Postrotary Nystagmus and those that allow an inference of vestibular processing including prone extension, supine flexion and balance, will be considered in this review.

2.5.1.1 Clinical assessment of the vestibular system

A standardised assessment of the integrity of the vestibular system through the Postrotary Nystagmus (PRN) Test has been described in the literature (Bundy, 2002; Fisher, et al., 1986). This specifically measures the discrete vestibular ocular reflex (VOR) through the elicitation of postrotary nystagmus which is believed to be an indicator of vestibular system functioning. The PRN test is administered when a child sits on a rotary board and the length of time postrotary nystagmus is assessed after spinning the child around at one revolution every two seconds for a total of 10 times (Ayres, 2012).

Some children may not be able to tolerate this rotary movement and can display an autonomic nervous system response such as excessive dizziness, nausea, vomiting, paleness and changes in respiration (Kawar, et al., 2005; Su, et al., 2015). These adverse effects need to be monitored carefully. Therapists need to be vigilant and look out for autonomic nervous system signs during rotation that could indicate overstimulation (Su, et al., 2015).

A low PRN score indicates low central nervous system responsivity to vestibular input and a high PRN score indicates insufficient central nervous system inhibition of the nystagmus reflex. Neither of these is favourable (Ayres, 2012).

2.5.1.2 Assessments from which vestibular processing can be inferred

In sensory integration theory, the prone extension position is one of the assessments used to measure the integrity of the vestibular system (Blanche, 2010; Gregory, 1981).

The prone extension is assumed by lying on the abdomen and simultaneously raising the head, arms and legs from the floor (Ayres, 2005; Fanchiang, 1989). The ability to assume and maintain the prone extension position is a strong indicator of intact vestibular and proprioceptive systems. If there is diminished vestibular and proprioceptive input to the neck and upper trunk, then holding this position will be effortful (Bundy, 2002). Areas to observe are the ability to assume the position quickly,

lift the shoulders, chest and arms off the floor, hold the head steady within 45 degrees of the vertical position, raise the distal one third of both thighs off the floor, maintain the knees in less than 45 degree flexion and talk out loud. Individuals ages six years and older should be able to hold this position for 30 seconds (Bundy, 2002; Gregory, 1981; Harris, 1981; Wilson, et al., 2000).

The supine flexion position is lying in supine and curling into a ball by flexing the knees, crossing the arms against the chest and lifting the neck. A head-lag (chin poking out) indicates that the righting reactions are poor, which in turn indicates vestibular dysfunction (Bundy, et al., 2002). Neck control is critical for the development of postural control. At two months of age neck co-contraction is developing which enables the visual, somatosensory and vestibular systems to develop in relation to neck control. A head-lag indicates that the vestibular and visual systems are not working together to realign the head with the body. Many children with learning disabilities present with low muscle tone, neck co-contraction and a head lag thus having difficulty in supine flexion position which is associated with vestibular system dysfunction (Magrun, 2016).

Static balance assesses the vestibular, proprioception and visual processing but cannot be used in isolation to assess the vestibular system (Ayres, 2012). The static balance from the Movement Assessment Battery for Children-2 (Movement ABC-2) is a standardised test (Henderson, et al., 2007) and can therefore be used as part of the assessment of the vestibular system as vestibular receptor from the macular receptors in the otolith organs are assessed during balance (Ayres, 2012). Thus, assessing balance pre and post-intervention will assist in determining the progress of the vestibular system while specifically looking at the otolith organs.

2.5.2 Assessment of postural control

Assessments of posture and postural control in children have been reported for those with more severe motor impairments such as cerebral palsy but not movement that

occurs during a seated task in children with vestibular processing dysfunction. Postural control can be assessed through the observation of supine flexion and prone extension as antigravity movements, as these movements are needed for efficient postural control. A child needs to have sufficient co-contraction of the muscles and muscle strength to move against gravity. These develop from infancy through the integration of reflexes in the prone and supine positions (Nichols, 2005).

The following integrated reflexes are needed to assume the prone extension position effectively:

- The tonic labyrinthine prone position results in an infant trying to counteract the flexors tone in the body by using the back extensors (Fiorentino, 1981).
- The Landau reflex then further develops the extension of the trunk to assist in the infant to push up against gravity from the prone position. It also assists in the development of the curves of the spine, thus an infant has a less kyphotic posture (Fiorentino, 1981).
- Righting reactions are needed to keep the head in the vertical midline no matter the position of the body (Fiorentino, 1981).
- The tonic labyrinthine supine position creates a balance between flexors and extensors as seen when a baby brings the limbs to midline when lying in supine (Fiorentino, 1981).

Postural control deficits related to vestibular function can be evaluated through assessing extensor muscle tone, prone extension position, proximal stability, supine flexion position and ability to move the neck into flexion against gravity, and equilibrium and postural ocular movements (Bundy, 2002). Postural changes over time and movement while sitting can also be considered. Many articles have researched seated posture by looking at the centre of pressure using a force platform (Igarashi, et al., 2016; Vuillerme & Nougier, 2004), however, this method is not always viable in a therapy setting. Other methods such as video recordings (Domljan, et al., 2010) or observational scales (Bennie, 2011) have been used to assess postural control which is easier to implement in private practice. There is a need for more research into

alternative ways to measure seated postural control such as using accelerometers to measure movement or a descriptive assessment to measure posture in children without severe motor impairments.

One way of testing in-seat movement is to use an accelerometer. The Actigraph accelerometer is one of the most popular accelerometers used in research (Atkin, et al., 2012). It measures motor activity through detection of movement (Rapport, et al., 2009). Actigraphs have a reliability of 0.90 to 0.99 if placed on the same individual in the same place (Tyron, 1985). It is a small (3.3 x 4.6 x 1.5 cm) lightweight (19 grams) device and is worn on an elastic band around the participant's waist over their clothing. It provides information regarding the intensity of movement and can be used to measure activity during sedentary activities by using low movement counts.

Erwin, et al. (2016) used an Actigraph accelerometer to analyse student's physical activity levels when sitting on stability balls compared to chairs and found stability balls did not elicit more physical activity than classroom chairs. Rapport et al (2008) also used the Actigraph accelerometer to determine the correlation between working memory and activity levels in boys with Attention Deficit Hyperactivity Disorder (ADHD) whilst sitting. It was found all children displayed higher activity levels, with the children with ADHD displaying more activity than the typically developing children. In this study, three accelerometers were used: on both ankles as well as on the non-dominant wrist (Rapport, et al., 2009).

2.6 Intervention for postural control and vestibular dysfunction

The various intervention methods used in occupational therapy to treat dysfunction of postural control and vestibular difficulties will be discussed.

2.6.1 Interventions for postural control

Most research on the treatment of postural control has been done on children with Cerebral Palsy. A systematic review by Dewar et al (2015) analysed 45 articles to

determine which interventions were beneficial to improve postural control in children with Cerebral Palsy. Hippotherapy was the most commonly reported approach and had moderate evidence in improving postural control for ambulant children. Other approaches that had moderate evidence were gross motor task training, treadmill training with no body weight support, trunk targeted training and reactive balance training. (Dewar, et al., 2015). Neurodevelopmental Therapy is a common method of treating postural control in children (Tekin, et al., 2018).

2.6.1.1 Neurodevelopmental Therapy

Neurodevelopmental therapy was developed by Berta and Karel Bobath in the 1940s to treat movement disorders. This approach provides normal movement experiences for children relying on three principles: facilitation, stimulation and communication. Thereby having an effect on postural control and balance (Tekin, et al., 2018). According to Tekin et al (2018), Neurodevelopmental therapy based posture and balance training were effective in children's gross motor skills over an eight week period when receiving therapy twice per week. However, Dewar et al (2015) found Neurodevelopmental Therapy to have weak evidence of its effectiveness.

2.6.1.2 Motor learning theory intervention

Motor learning theory has become a foundation for occupational therapists treating children with postural control difficulties, with the Neurodevelopmental treatment approach being based on its principles (Nichols, 2005). Motor learning theory first addresses the treatment of musculoskeletal abnormalities that can result in poor postural alignments such as joint range of movement and muscle tone. Facilitating antigravity movements of the trunk and neck are done in a graded fashion using a variety of equipment such as therapy balls or wedges, as well as handling techniques to allow for the correct muscle movement. Postural reactions are facilitated by moving the child's centre of mass over the base of support using different speeds and surfaces

to elicit the desired righting reaction or equilibrium reaction. Reaching out of the base of support allows for a compensatory response (Nichols, 2005).

Sensory organisation is used by targeting the sensory system that impacts on a child's balance and postural control. The therapist will address the visual system or somatosensory system by either occluding vision or altering standing surfaces so as to challenge the child's somatosensory systems, relying on the vestibular system. Facilitating anticipatory postural control is done by working on weight shift, displacement and reaching so that the child can experience different movements and adjust their body appropriately (Nichols, 2005). Therapy activities need to be motivating and allow for appropriate feedback so that the child can adjust and adapt to achieve the desired postural response (Nichols, 2005).

2.6.2 Intervention for vestibular processing dysfunction

Vestibular processing deficits in occupational therapy are usually based on the sensory integration frame of reference (Bundy, 2002). Jean Ayres developed the theory of sensory integration and how dysfunction in the processing of information from the sensory systems can impact on daily activities (Ayres, 1982). Intervention usually focuses on activating the vestibular system, along with other sensory systems, pre-activity or during an activity. Adaptations to the environment can also be used to gain the desired sensory input (Bundy, 2002).

2.6.2.1 Ayres sensory integration

Ayres Sensory Integration® (ASI) has become a specific approach used to treat children with sensory integration disorders. This approach needs to be distinguished from sensory stimulation or sensory-based approaches through a fidelity measure (Parham, et al., 2007). Therapists require training and supervision in this approach and have to be a certified ASI practitioner (Parham, et al., 2011). The treatment has to be child-led in a safe environment that can promote learning and new experience

through play. The practitioner has to read the child's cues and scaffold and adapt the environment to ensure a just-right challenge and adaptive response (Schaaf & Mailloux, 2015). Treatment generally takes place in an environment that has a variety of equipment to stimulate the vestibular, proprioceptive and tactile systems such as swings, scooter boards, ramps, mattresses and blocks. The therapist must present these sensory opportunities to the child to support self-regulation, movement in space, sensory awareness and praxis. The therapist does not choose these activities but guides the child's choice by suggesting ideas to increase or decrease the challenge. This is done in a playful manner whilst developing a therapeutic relationship (Parham, et al., 2011).

When treating the vestibular system, the therapist will assist in scaffolding the just-right challenge by varying the amount and type of vestibular input that the child needs.

2.6.2.2 Sensory-based interventions

Sensory-based intervention uses the principles designed by Ayres but does not meet all the criteria of the Fidelity Measure. The intervention may be therapist- directed and not child-directed, stimulating only one of the sensory systems with the child not always being involved in the choice of activity (Toyama, 2013). Sensory-focused interventions target one or more specific sensory systems with the goal of creating an optimal arousal level for a child (Toyama, 2013). Research has shown positive changes in sensory-based interventions improving behaviour, social and sensorimotor skills (Case-Smith & Arbesman, 2008). According to Toyama (2013), some of these interventions used by occupational therapists include craniosacral therapy, Therapeutic Listening, Wilbarger Protocol, The Alert Program, DIR Floortime and Astronaut Training.

2.6.2.3 Adapting the environment

One of the sensory-based interventions includes changing the environment by adapting it to provide a child with sensory input (Toyama, 2013). Individuals need a certain amount of sensory input throughout the day. Adapting the environment can be done through careful analysis and planning by an occupational therapist in consultation with the child, caregiver, and teachers (Wilbarger & Wilbarger, 2002).

One of the ways to adapt the environment is to offer alternative seating. Most current literature describes the use of therapy balls or a Disc 'O' Sit cushions to engage the proprioceptive and vestibular sensory systems when seated in the classroom. The use of this equipment is based on the principle of how self-initiated input can improve poor balance, poor posture and constant moving, as well as poor attention related to a lack of proprioceptive and vestibular input (Schilling, 2004).

There are several studies done on adaptive seating in the classroom using ball chairs and or Disc 'O' Sit cushions. Although these cushions and chairs provide a less stable base of support whilst seated, they have been found to be helpful in children with Attention Deficit Hyperactivity Disorder (ADHD) with regards to improving focus, sustained sitting and school performance (Olson, 2015; Schilling, et al., 2003; Schilling, 2004), although postural control was not assessed in these studies. Pfeiffer reported similar improvements in her study using Disc 'O' Sit cushions (Pfeiffer, et al., 2008) and the lack of an overall improvement in on-task behaviour and in-seat behaviour in a typical classroom. Using stability balls confirms the principle that the intervention is beneficial for children with sensory processing deficits (Olson, 2015). Bagatell, et al (2010) found that the children with Autism Spectrum Disorder (ASD) who were not sensory-seeking but had difficulties in postural control and muscle tone found it too challenging to sit on the ball chairs and tended to slouch. They preferred sitting on a regular chair, while children who did have a sensory-seeking profile improved their in-seat behaviour using ball chairs (Bagatell, et al., 2010).

2.7 The Astronaut Training Protocol

The Astronaut Training Protocol was designed, based on the sensory integration framework, to stimulate and integrate the vestibular, visual and auditory systems and expand on treatment strategies and clinical reasoning (Kawar, et al., 2005). The Astronaut Training Protocol provides stimulation to the vestibular, auditory and visual systems and is used as an adjunct to sensory integration based occupational therapy (Toyama, 2013).

The vestibular system is stimulated through rotation, inversion and linear movement. Rotation is used to activate the semi-circular canals of the vestibular system by the therapist rotating the child once every two seconds in time with the Astronaut Training music. This is done in sitting and side lying on the left and right sides. Through rotation, the ocular muscles are activated due to the postrotary nystagmus. The visual system is stimulated by using smooth pursuit and saccadic eye movements horizontally, vertically and diagonally, as well as convergence and divergence. This is done by following moving penlights held by the therapist. Throughout the programme, specific music tracks are played to stimulate the auditory system to encourage spatial awareness and timing of movement (Kawar, et al., 2005). Vestibular and core activation activities are used at the end of the programme to further activate and regulate the vestibular system (Kawar, et al., 2005).

According to Toyama (2013), this programme is used by 40.2% of sensory integration occupational therapists in the United States of America. 63.2% of therapists use it to stimulate postural-ocular control, 57.9% for oculomotor control and 46.4% for balance skills. On average, this programme is used for up to three months as a sensory-based intervention. Although this programme is well known in America and other countries, there is no published research showing the effectiveness of the programme. There is a need for evidence-based research to assist in the therapist's clinical decision-making when selecting treatment approaches.

The Astronaut Training Protocol may be beneficial in the direct treatment of the vestibular system due to the direct stimulation of the semi-circular canals and otolith

organs. In terms of treating postural control, it can be hypothesised that using the core activities, following vestibular stimulation, can stimulate anti-gravity movements to strengthen the trunk and neck extensors and flexors needed to keep an upright posture. These activities require the appropriate feedback and anticipatory response for the child to adjust their body to master the activity. These activities have a theme and music, which children find enjoyable thus assisting in motivation and volition which is an important component in the motor learning theory (Nichols, 2005). This research will focus on whether changes in vestibular function through the use of the Astronaut Training Protocol will have a change in postural control.

2.8 Summary

Children need to be able to maintain an upright posture in the classroom to ensure appropriate learning and engagement. Without adequate postural control, poor in-seat posture and in-seat movement can be observed. As seen in the literature, the vestibular system plays an important role in the development of postural control. While adapted strategies have been used in the classroom, the research does not prove that it can assist all children who have difficulties in postural control. No research has been published regarding the use of the Astronaut Training Protocol and whether it can have an effect on the vestibular system and postural control. Therefore, this study will assess whether using a bottom-up approach of stimulating the vestibular systems through the use of the Astronaut Training Protocol can have an impact on a child's vestibular processing, in-seat posture and in-seat movement at the table and whether there is a carryover after the withdrawal of the Astronaut Training Protocol.

CHAPTER 3: METHODOLOGY

3.1 Research design

A single subject quasi-experimental research design was used in this study. This design is widely used in fields such as applied behavioural analysis, rehabilitation and psychology, (Kinugasa, et al., 2004) and has been seen to be beneficial in treatment research in occupational therapy (Ottenbacher, 1986). Single subject research is used to discover a causal relationship by manipulating the independent variable and the careful measurement of the dependent variable to provide good internal validity (Lammers & Badia, 2004). This research design involves studying a single subject or system (small group) by taking frequent repeated measures of one or more of the dependent variables and then withdrawing the independent variable. This allows for a more thorough analysis of the effectiveness of an intervention programme on a specific individual as opposed to looking at the average performance across a group of participants (Ottenbacher, 1986).

The advantages of this study are:

- can be implemented within a clinical setting where therapists have access to a smaller sample size of participants;
- has a rigorous design as several repeated measures are used to track the individual's progress. This method is effective at analysing a new treatment method and comparing the effectiveness of the treatment to an individual's baseline;
- the researcher can adapt and change the intervention according to the individual's needs (Kinugasa, et al., 2004; Ottenbacher, 1986).

A disadvantage of this study design is that it is difficult to generalise results to the population.

An ABA design was used with the three phases being a Baseline phase (A), an Intervention phase (B) and Withdrawal from the treatment phase (A). This design allowed the researcher to establish whether the Astronaut Training Protocol for children with vestibular difficulties was effective. The study used assessments of performance on balance, Postrotary Nystagmus, in-seat posture, and in-seat movement at the start and end of each phase. The assessments were completed at the start of the Baseline phase (A), the start of the Intervention phase (B) and at the start of the Withdrawal stage (A). The participants' performances, using these assessments, were re-evaluated after the Withdrawal phase (A) so as to establish whether there was carryover once the intervention was withdrawn.

In line with repeated measurements required for single subject research, a clinical observation assessment of prone extension position and supine flexion position allowed for vestibular processing to be evaluated at the end of each treatment session over the data collection period. The participants received their routine sensory based occupational therapy intervention for the first four sessions during the Baseline (pre-Astronaut Training phase) (A), with an Astronaut Training intervention added to the routine occupational therapy during the eight-session Intervention phase (B). The Astronaut Training was withdrawn in the Withdrawal phase (A) over a four-session period while routine occupational intervention continued (See Figure 3.1).

There were 16 treatment sessions over the duration of the data collection: Phase A consisted of a four-session baseline, Phase B was the Intervention stage during which the Astronaut Training Protocol was applied over eight sessions, and Phase A the withdrawal of the Astronaut Training Protocol over four sessions. A baseline and withdrawal of four sessions were chosen as it was felt this would be sufficient time to monitor any changes without the Astronaut Training Protocol. An eight-session intervention period was chosen based on the researcher's clinical experience using this programme, it was felt this would be enough time to see changes using the Astronaut Training Protocol.

Sensory-based occupational therapy remained consistent throughout all of the sessions. Assessments of the vestibular system (balance, Postrotary Nystagmus test, in-seat posture and in-seat movement) were conducted during session one, four, 13 and 16, while prone extension and supine flexion positions were used at the end of each of the 16 sessions to determine progress of the vestibular system over time.

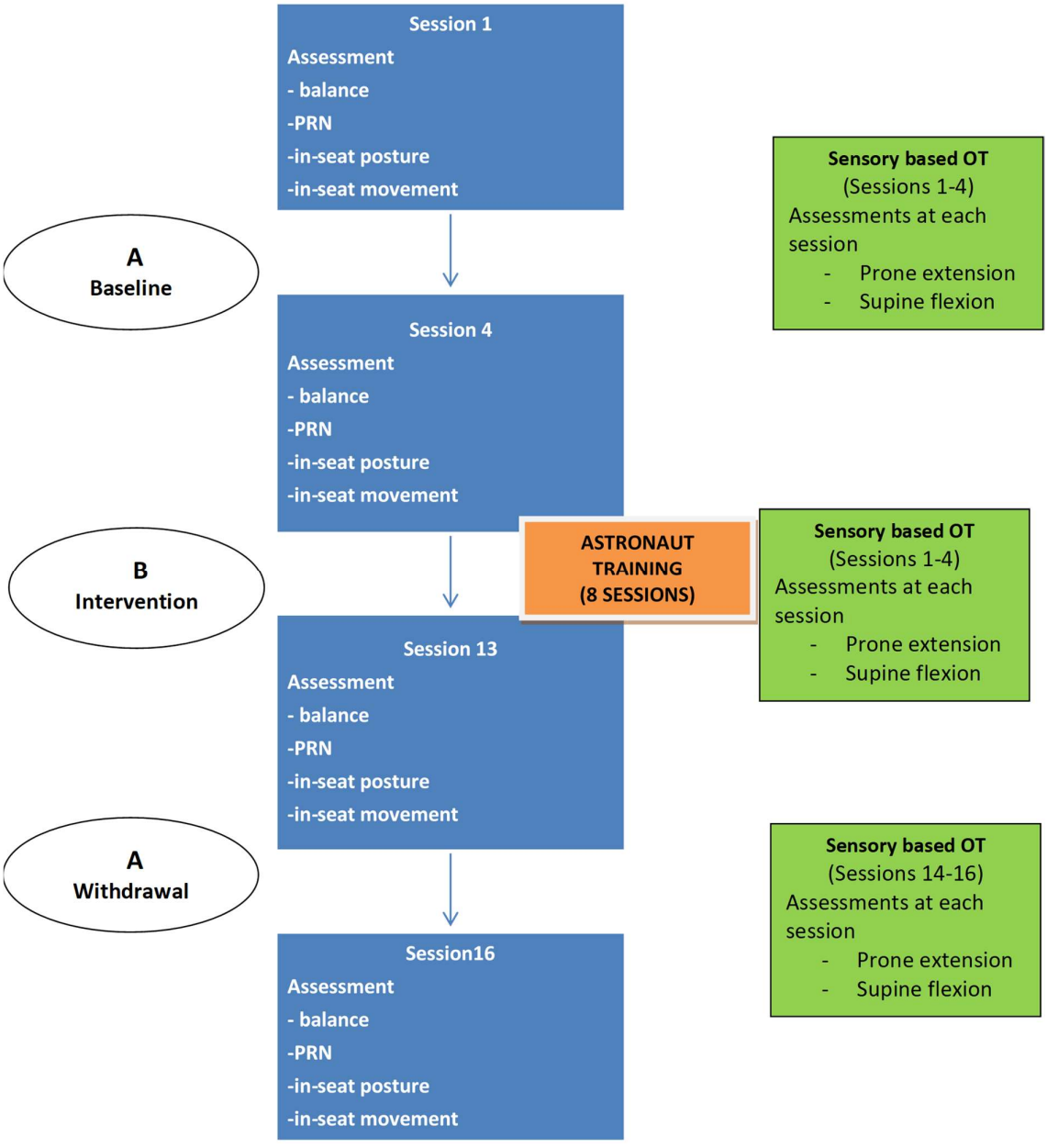


Figure 3.1 Summary of the ABA design

3.2. Selection of participants

3.2.1 Study setting

Occupational therapy intervention took place at a private occupational therapy practice in Johannesburg, South Africa. The Astronaut Training sessions took place at a convenient location for the participants and parents, either in the gross motor occupational therapy room at the private practice, their home or in a small room at the school. When the intervention took place in a smaller room i.e. at the school or home environment, it had to be big enough to use a scooter board as part of the intervention. The assessments took place at the occupational therapy practice rooms, again either in the gross motor room or at a desk for the table-top activities. The gross motor room was equipped with suspension points for the use of swings. The varied study settings did not negatively impact on the implementation of the intervention programme as the implementation of the Astronaut Training Protocol was kept consistent throughout.

3.2.2 Study population

The population were children aged between five years, three months and six years, four months currently attending occupational therapy at a private practice in Johannesburg. This age range is commonly referred to occupational therapy before children start formal school in grade one and therefore this age range made up most of the researcher's case load. From the researcher's experience, a lot of referrals to the practice at this age are from teachers who are concerned about fidgety behaviour and poor posture at the table. At this age, the researcher found that children are able to engage in a structured therapy programme whereas younger children prefer child-led activities. The data collection took place at the private practice over the course of a year, between August 2017 and August 2018.

3.2.3 Sampling method

Permission to recruit participants for the study was received from a private paediatric sensory integration practice in Johannesburg (Appendix A). A convenient sampling method was used. The sample was convenient as only one occupational therapist's caseload was analysed to identify participants. Participants who displayed problems with in-seat posture and in-seat movement at the desk (e.g. fidgeting, needing frequent movement breaks or slouching) were identified and difficulties in vestibular processing were analysed through previous assessment records via a screening questionnaire (Appendix B). This questionnaire included the participant's age, gender, grade, date of birth, ability to perform and maintain supine flexion and prone extension positions based on observations from their records, and whether or not the occupational therapist had identified the child as having poor posture or excessive in-seat movement. The children had to meet the following inclusion and exclusion criteria in order to be included in the study.

3.2.1.1 Inclusion criteria

The child was included if they:

- scored two or below on the supine flexion and prone extension clinical observation assessments (Ayres, 2005);
- attended weekly or twice-weekly occupational therapy;
- displayed difficulty in in-seat posture or in-seat movement during table-top activities as reported by the occupational therapist, parent or teacher;
- displayed concentration difficulties either diagnosed or undiagnosed. Children with concentration difficulties such as ADHD may display fidgety behaviour (American Psychiatric Association, 2013)
- both they and their parents consented to them being participants in the study.

3.2.1.2 Exclusion criteria

The child was excluded if they had:

- peripheral vestibular difficulty. Peripheral vestibular disorders such as benign paroxysmal positional vertigo, vestibular neuritis or Meniere's disease were excluded as the Astronaut Training Protocol was not designed to treat these diagnoses;
- severe tactile defensiveness (as they may not be comfortable and willing to wear an accelerometer around their waist);
- epilepsy. Using vestibular stimulation should be cautioned with these children as it can trigger a seizure (Xue LY, 2006);
- severe visual or auditory impairments such as blindness or having cochlear implants;
- severe behavioural difficulties (as they may not be willing to participate in a structured intervention programme).
- Brain injuries such as Cerebral Palsy.

3.2.4 Sample size

Total population sampling of children with in-seat behaviour deficits and vestibular deficits identified over a 12 month period in the occupational therapy practice were recruited into the study. There is no stated procedure for determining the sample size of the single subject research study and literature indicates it can be anywhere between three and 10 participants (Kinugasa, et al., 2004). A sample of five participants was identified from the researcher's total caseload, who met inclusion and exclusion criteria and included in the study. There was no drop out from the study. Participants who were identified had been in occupational therapy for more than three months.

3.3 Research instruments

3.3.1 Screening questionnaire (Appendix B)

The treating occupational therapist, who was also the researcher, completed the screening questionnaire to identify possible participants based on the child's ability to assume the prone extension, supine flexion position and whether they were fidgety during table-top activities. Demographics of age, gender and grade were recorded. Names, email address and contact phone numbers of parents were recorded by the researcher and this information was kept with the parent consent forms in a separate and secure location from the participants' assessment forms. This was done to ensure confidentiality.

3.3.2 Pre and post-intervention assessments

Participants attended occupational therapy once per week. Participants were assessed at the start of the Baseline phase (A) (session one), then again after four occupational therapy sessions at the start of the Intervention phase (B) (session four), then after eight Astronaut Training sessions (session 13) at the start of the Withdrawal phase (A), and lastly after four occupational therapy sessions (session 16) at the end of the Withdrawal phase (A).

3.3.2.1. One-leg balance (Appendix C)

Balance requires the integration of input from physiological, neuromotor and sensory systems (Condon & Cremin, 2014). Balance requires appropriate biomechanics such as the base of support and stability of the feet and ankles, and hip co-contraction (Magrun, 2016). Static balance includes vestibular, proprioception and visual processing, particularly the macular receptors in the otolith organs of the vestibular

system (Ayres, 2012). Vestibular impulses need to be integrated with the vestibular-spinal tracts and reticular-spinal tracts. These tracts play a role in postural adjustments in the trunk and upper limbs, and to a smaller extent on the lower limbs which have an impact on, for example, one leg balance. Children with vestibular difficulties may have an over-reaction to equilibrium demands and try to over-compensate. Children with proprioceptive difficulties tend to hold their body parts close together to provide additional support, such as fixating the raised leg to their other leg or holding their raised leg to their body. The lack of integration between the vestibular and proprioceptive systems can cause poor equilibrium, righting reactions and thus poor postural control (de Quiros & Schrager, 1978). Based on the assumptions of de Quiros (1978) that one-foot balance indicates the status of the vestibular-proprioceptive systems, it would follow that children who have an improvement in one-leg balance reactions after the intervention, may be demonstrating improved vestibular-proprioceptive processing.

The balance assessment that was used was chosen for its quick administration. The balance subtest from Sensory Integration and Praxis Test was considered and preferred due to its reliability and validity, however, the administration was too time-consuming and expensive, and therefore not a viable assessment in this research.

The Movement Assessment Battery for Children-2 (Movement ABC-2) was designed to identify motor difficulties in children and the impact this can have on their activities of daily living. It assessed Manual Dexterity, Aiming and Catching, and Balance (Henderson, et al., 2007). The Movement ABC-2 has a balance subtest assessing static and dynamic balance. For this research, the static balance subtest was used which required balancing on one leg with eyes open. Dynamic balance was not used due to time constraints and it was felt assessing dynamic balance required bilateral coordination (Ayres, 2012) and proprioceptive processing which was not the being assessed in the study. The one-leg balance test is widely used and one of the oldest tests of balance (Mancini & Horak, 2010). Age Band one was used due to the participants' ages. The participant was allowed one practice attempt on each leg for up to 15 seconds. The examiner then recorded two attempts for each leg after which

the best score was used. The timing was discontinued at 30 seconds or if the child touched the floor with the free foot, touched the supporting leg with the free foot, such as hooking or winding the free leg, or moved the standing foot, heel or toe from its original place. Both left and right legs were tested. Raw scores were converted into standardised scores (Henderson, et al., 2007) and then z scores. Z scores between -1 and +1 are within the typical range.

The Movement ABC-2 is a popular assessment used to identify motor impairments in children from three to 16 years. The reliability is based on the original Movement ABC which is sufficiently similar in content and is therefore relevant (Henderson, et al., 2007). The test-retest reliability of the balance subtest was 0.73 and correlation scores ranged from 0.73 to 0.84 for each subtest which totalled test-retest reliability of 0.80 for the total test of the Movement ABC-2 and interrater reliability of 0.95 (Henderson, et al., 2007).

3.3.2.2 Postrotary Nystagmus (PRN) subtest (see Appendix D)

The Postrotary Nystagmus (PRN) Test assesses the integrity of the vestibular-ocular reflex, provided there are no peripheral vestibular problems. A low PRN score indicates a low central nervous system responsivity to vestibular input, whilst a high score indicates poor inhibition of the central nervous system on the reflex (Ayres, 2012). Neither of these is favourable.

The PRN test is one of the standardised subtests of the Sensory Integration and Praxis Test (SIPT). This test requires a nystagmus board (a wooden board attached to a ball-bearing mechanism to allow for rotation like a Lazy Suzy). In this case, the nystagmus board was positioned on the floor about one meter from a blank wall with even lighting. The child sat in the centre of the board crossed legged with eyes open and the researcher sat to the child's left. The child's head was tilted forwards 30 degrees by the researcher (Ayres, 2012) thus assessing the horizontal semi-circular canal (Kawar, et al., 2005). The child was then rotated counter-clockwise maintaining a constant

velocity of one rotation every two seconds 10 times i.e. 10 rotations in 20 seconds. On completion of the 10 rotations, the child was stopped facing the wall and told to look at the wall. As soon as the board was stopped, the researcher recorded the length of the Postrotary Nystagmus (eyes jerking side to side) using a stopwatch. The child was allowed to rest for 30 seconds before the procedure was repeated to the right (clockwise). The examiner asked how the child felt and explained that it is normal to feel dizzy (Ayres, 2012). The examiner recorded the time to the nearest second. Scores were converted to z scores using the Sensory Integration and Praxis Test computerised scoring software. Again, scores between -1 and +1 are within the typical range.

This assessment was completed after the balance assessment as some children may get disorganised by the rotational input. Stimulating the vestibular system can have an adverse effect on balance. This assessment was administered by a SIPT certified occupational therapist. The assessment has good interrater reliability of 0.98 (Ayres, 2012; Ayres, 1976) and test-retest reliability of 0.83 (Ayres, 1975) and 0.80 (Kimball, 1981).

3.3.2.3 In-seat posture assessment

The participants' in-seat behaviour was assessed by determining in-seat posture and in-seat movement during a 10-minute table-top task they were asked to complete while seated. The participants were re-assessed in the same occupational therapy room, at a similar time of day using the same chair and desk each time. No adaptations to the chair or desk such as Disco sit cushions or ball chairs were used.



Figure 3.2 The desk and chairs used in the posture assessment.

The task for the assessment of in-seat posture

The task set for the participants during the 10-minute table-top activity were the same throughout the four assessments – a pegboard activity. The child could choose one of six pictures to copy for the duration of 10 minutes. A pegboard was chosen as it is cognitively demanding and challenges the participants' visual perceptual skills. The same activity can be used in different ways by changing the picture required to copy. It can be graded by using a simpler picture or grading the amount of assistance from the occupational therapist. Many schools and occupational therapists have pegboards and so this is a familiar activity. According to Bennie (2011), a child will use a more upright posture when involved in a cognitively demanding task as opposed to a passive activity. Thus, using the pegboard required active cognitive engagement and keeping the activity consistent helped track the change of the participants' in-seat posture and in-seat movement. Allowing the participant to choose the activity card enabled the participant to feel in control, motivated and find more meaning in the activity.

The pegboard was set up by placing the pegboard directly in front of the participant with the picture card propped up behind the pegboard (Figure 3.3). This allowed the activity to be in the child's midline. The participant was first encouraged to collect all the pegs needed for the picture. Half the pegs were placed on either side of the

participant to avoid placing demands on their midline crossing which may impact on their posture.



Figure 3.3 Set up of pegboard activity for the in-seat posture assessment

Video of in-seat posture

A full lateral view from the non-dominant side was videoed. The video camera was placed approximately two to three meters away and the recording started once the participant was seated and engaged in the activity. The participant's posture was videoed for the first 10 minutes during a table-top activity during their occupational therapy session as according to Domljan, et al. (2010) research, children tend to fidget most in the first 10 minutes during static seating. Children generally spend 10 to 20 minutes involved in a table-top activity within their occupational therapy session to address visual perceptual and fine motor skills, therefore this 10-minute assessment did not negatively impact on their therapy time.

Analysis of in-seat posture

In-seat posture was measured by videoing the participant with their posture being analysed via a posture assessment at two separate points during the 10-minute table-

top activity: at 7.30 minutes in (posture 1) and then again at 9.30 minutes in (posture 2). Scores closer to zero indicate optimal posture.

The researcher analysed the participants' posture from the lateral view to assess their ability to maintain an upright position against gravity. To analyse the posture, a posture assessment was developed (Appendix E) based on the Chailey Levels of Postural Ability (Pountney, et al., 2004). The video was transferred to a laptop and screenshots were taken at the 7.30-minute mark and at the 9.30-minute mark (according to the time on the assessment video – *see figure 3.4)*. This helped prevent experimenter's bias. The posture at each time was analysed according to descriptive data: knees and feet positioning, buttocks in contact with the chair, pelvic girdle positioning, hip position, trunk position, shoulders, head alignment and engagement of arms in the activity. A score of one was given for each observation on the checklist. This was then totalled to give the overall score for posture one (7:30 minutes) and posture two (9:30 minutes).

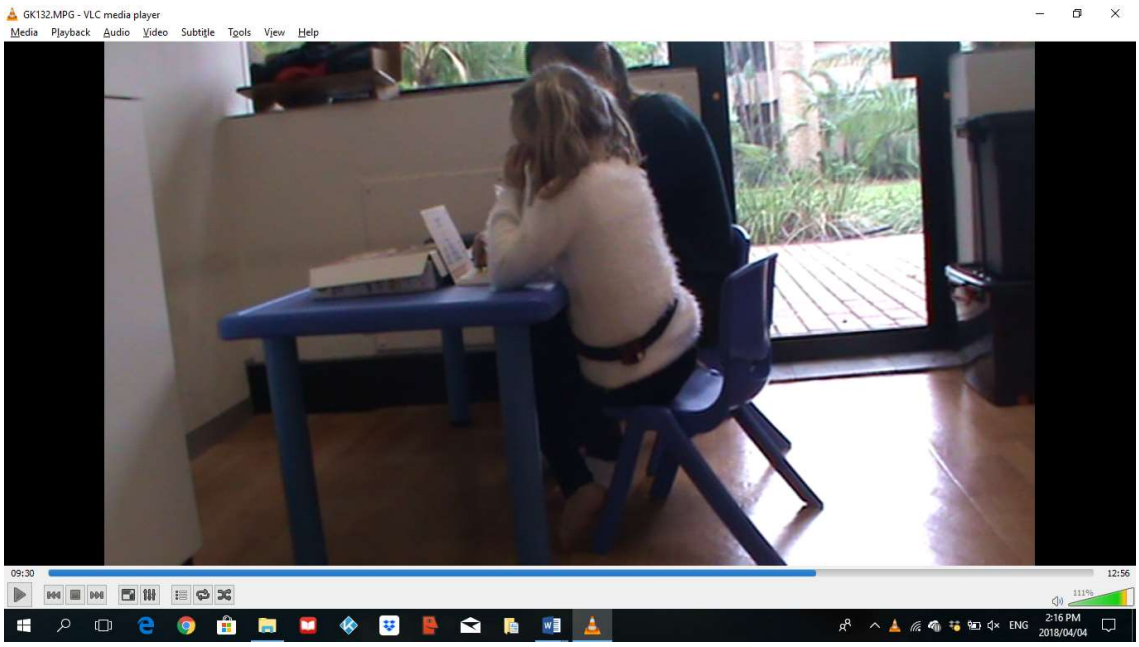


Figure 3.4 – Screenshot of posture assessment at 9:30 minutes into the activity.

3.3.2.4 In-seat movement assessment

The Actigraph accelerometer (ActiGraph GT3X+, ActiGraph, Pensacola, FL) was used to assess movement of the trunk while the child was seated. This is a common and objective method for measuring physical activity and movement. It is one of the most popular accelerometers used in research (Atkin, et al., 2012) and it measures motor activity through detection of movement (Rapport, et al., 2009).

The accelerometer is a small (3.3 x 4.6 x 1.5 cm) lightweight (19 grams) device and is worn on an elastic band around the participant's waist over their clothing. It provides information regarding the intensity of movement and can be used to measure sedentary activities by using low movement counts. The accelerometer was initialised to record at a sample rate of 100Hz in 10-second segments. The participant's in-seat movement was isolated and tracked assessing three axes, thus measuring vertical, horizontal and perpendicular movement. This device was worn for the entire duration of the 10-minute table-top activity. To activate the device and analyse the data, the Actilife software needed to be downloaded and the start and stop time was initialised to activate the accelerometer for the desired time. Data was then downloaded and saved as an Excel file (Actigraph, 2016).



Figure 3.5 : The Actigraph Accelerometer on elastic band worn around the participant's waist.

Actigraph Accelerometers have a reliability of 0.90 to 0.99 if placed on the same individual in the same place (Tyron, 1985). The vector magnitude scores from the Actigraph Accelerometer combined Axis I, II and III, thus analysing overall fidgety movements. A lower score indicates less in-seat movement.

3.3.3 Repeated measure assessments

The following assessments were used as repeated measures at the end of every one of the 16 occupational therapy and Astronaut Training sessions over the three phases of the study. This allowed for a baseline, helping to track both progress of the intervention as well as carryover of the intervention.

3.3.3.1 Clinical observations

Clinical observations are a group of tests that can be used to assist in the interpretation of test results on the SIPT (Ayres, 1976). Tests used to interpret the integrity of the vestibular system are the prone extension and supine flexion positions, (Ayres, 2005; Fanchiang, 1989). At the end of each treatment session, the participants were videoed by the treating occupational therapist while positioning themselves in prone extension and then supine flexion positions. These videos were taken from a lateral view and each video was assigned a code and shuffled during scoring to prevent examiner's bias.

The videos were scored by two experienced paediatric occupational therapists based on the time the position was held and quality of the position. The scoring criteria for time was the number of seconds the participants could hold the position. Scoring criteria for quality was based on a three-point scoring scale which was and validated in a study by Fanchiang (1989) this scale differed slightly from Gregory (1981). These norms used for the scoring were based on research from the 1980s. There is evidence that these norms may need to be revised, as children's gross motor development has deteriorated due to the fact that children are more sedentary due to screen time and spending less time in gross motor play (Hanscom, 2016). Hanscom's (2016) pilot study discovered that only 8% of children displayed the same core muscle strength when compared to the norms in the 1980s. When researching the norms for this study, there were discrepancies according to various references and therefore the norms chosen for this study were in the lower limit.

Two additional criteria were also added, based on the researcher's clinical experience. It was noted that participants frequently used compensatory movements and fixation which was not on the original assessment. These criteria were discussed and included to allow for the sensitivity of scoring. Compensatory movements (the rocking of the body or movements of the limbs) and fixation (fixating at the neck, shoulders or limbs) are associated with poor vestibular function (Blanche, 2010).

- **Prone extension position (Appendix F)**

The prone extension position is assumed by lying on the abdomen and simultaneously raising the head, arms and legs from the floor (Ayres, 2005; Fanchiang, 1989). The ability to assume and maintain the prone extension position is a strong indicator of intact vestibular and proprioceptive systems. If there is diminished vestibular and proprioceptive input to the neck and upper trunk, then holding this position will be effortful (Bundy, et al., 2002). Scores were given from one to three. Three being the preferred score.

Areas to observe are:

- Assumption: the ability to assume the position quickly
    - 3- smoothly quickly and all body parts
    - 2- segmentally
    - 1-head, hands and or knees on the mat
- Head: hold the head steady within 45 degrees of the vertical position
    - 3- face vertical (>45°) and held steady
    - 2- face raised less than 45° or not held steady
    - 1- head on the mat
- Upper trunk: lift the shoulders, chest and arms (flexed at 90 degrees at the elbow) off the floor;
    - 3- definite arch and elbows even with the back of shoulders
    - 2- back appears flat or minimally arched, elbows forward of shoulders
    - 1- upper trunk on the mat
- Thighs: raise the distal one-third of both thighs off the floor;
    - 3- clearly off the mat, from mid-thigh distally
    - 2-barely off, a sheet of paper can be slid under knee but not much above knees
    - 1- thighs on the mat
- Knees: maintain the knees in less than 45-degree flexion
    - 3- slightly bent (45° or less)

    - 2-definitely flexed (50° or more)
    - 1- knees on the mat
- Maintains for full 30 seconds: judge quality of breath when counting out loud
    - 3- moderate exertion expended- able to count without too much effort
    - 2- considerable effort / fixates at mouth, shoulders, arms, breath or moving within the position.
    - 1- unable to maintain position- cannot reach age norm time

Two additional criteria were added by the researcher

- Compensatory movements: rocking, using momentum
    - 3- none
    - 2- some rocking/movements
    - 1- excessive rocking or use of momentum to maintain
- Fixation: shoulders elevated or retracted, hands, toes
    - 3- none
    - 2- less than 50% of time
    - 1- fixates more than 50% of the time held

Age norms vary according to research with some indicating that those six years and older should be able to hold this position for 30 seconds (Bundy, 2002; Gregory, 1981), whereas other sources state it can be maintained for 60 seconds (Gregory-Flock & Yerxa, 1984). The majority of five-year-olds can maintain this position for 30 seconds (Gregory-Flock & Yerxa, 1984). For this study, it was decided to use 30 seconds for ages five to eight years as the norm to base the quality scoring criteria. The total time the position was held was also recorded to determine whether a change in the duration of maintaining the position was seen.

This assessment has been standardised and is scored on a three-point scoring scale for the first seven items (Appendix F), with a 0.6-0.8 level of internal consistency reliability (Fanchiang, 1989).

- **Supine flexion position (Appendix G)**

This position involves the participant lying in supine and curling into a ball by flexing their knees, crossing arms against the chest and lifting the neck (Fanchiang, 1989; Ayres, 2005). Input from the vestibular system is closely related to the position of the head (de Quiros & Schrager, 1978). Observation of a head-lag (chin pocking out) indicating poor righting reactions often indicative of vestibular dysfunction (Bundy, 2002). The three-point scoring system for six items was used to assess the quality of the movement (Appendix G) (Fanchiang, 1989). The higher score is the preferred.

Areas to observe are:

- Assumption
    - 3- smoothly quickly and all body parts
    - 2- segmentally
    - 1- Head or feet not lifted
- Head: face vertical
    - 3- Face vertical (>45°) and held steady (chin tucked in)
    - 2- Face raised less than 45° or not held steady (chin poke)
    - 1- Head on the mat
- Upper trunk
    - 3- shoulders raised at least 45°
    - 2- shoulders raised less than 45° but off the floor
    - 1- shoulders remain on the floor
- Buttocks
    - 2- buttocks clearly off the mat
    - 1- buttocks on the mat
- Maintains for full 30 seconds: judge quality of breath when counting out loud
    - 3- moderate exertion expended- able to count without too much effort
    - 2- considerable effort – fixates at mouth, shoulders, arms, breath or moving within the position,
    - 1- unable to maintain position- cannot reach age norm time

Two additional criteria were added by the researcher

- Compensatory movements: rocking, using momentum
    - 3- none
    - 2- some rocking
    - 1- excessive rocking or use of momentum to maintain
- Fixation: toes, holding arms, clenching jaw, neck
    - 3- none
    - 2- less than 50% of time
    - 1- fixates more than 50% of the time held

This assessment has been standardised and the position can be used with confidence in children from the age of six years. According to Fraser (1986), five-and-a-half to six-year-olds could hold this position for 30 seconds and found the interrater reliability was 0.99 and test-retest reliability was 0.96 for this position. Internal consistency reliability of 0.6 to 0.7 was reported using a six-point scale by Fanchiang (1989). For this study, it was therefore decided to use 30 seconds as the norm for ages five to eight years.

3.4 Interventions for vestibular processing dysfunction

3.4.1 Routine sensory integration based occupational therapy

Sensory integration is a commonly used framework in paediatric occupational therapy (Ayres, 1972; Green, et al., 2006; Harrington, et al., 2006; Lane & Schaaf, 2010). Dr A. Jean Ayres studied sensory integration and how difficulties in tactile, vestibular and proprioceptive systems negatively impact on a child's day-to-day functioning. Her therapeutic approach emphasised being child-led, providing a safe and stimulating environment with the just right challenge to facilitate an adaptive response through play in the child (Ayres, 1976). Enriched sensorimotor experiences that offer a just

right challenge to enhance the brain's ability to process information and provide a groundwork for learning (Lane & Schaaf, 2010).

Sensory integration-based therapies are common among paediatric occupational therapists. These therapies are thought to provide vestibular, proprioceptive, auditory and tactile input to assist in organising the sensory system. Therapeutic devices such as Therabrushes, swings and balls are used to provide these inputs (Zimmer & Desch, 2012). Ayres Sensory Integration (ASI®) Therapy requires the therapist to adhere to 10 fidelity criteria: Ensure the child's physical safety, present sensory opportunities, assist the child in maintaining appropriate levels of alertness, challenges postural, ocular, oral or bilateral integration function, challenges motor planning, collaborates in activity choice, provides the just-right challenge, ensures activity is successful, supports the child's intrinsic motivation and establishes a therapeutic relationship. Problem-solving and planning how to use the environment facilitates an adaptive response (Parham, et al., 2011).

To reach these criteria and facilitate an adaptive response, the environment requires a large space with suspended equipment such as swings, scooter boards, ramps, balls and soft mattresses. Occupational therapists are required to undergo post-graduate training to become certified in ASI®. During sensory integration-based occupational therapy, most but not all of the 10 criteria are met.

All participants received occupational therapy by the same occupational therapist who implemented the Astronaut Training Protocol. This therapist was qualified in ASI® as well as other sensory-based interventions such as the Astronaut Training Protocol. As stated, the treatment took place in the therapy room at the private practice utilising the above-mentioned equipment. Participants' occupational therapy time was either 45 or 55-minute sessions which they generally attended once per week, and their therapy time was kept consistent throughout the research. Occupational therapy goals for each participant can be found in Appendix H.

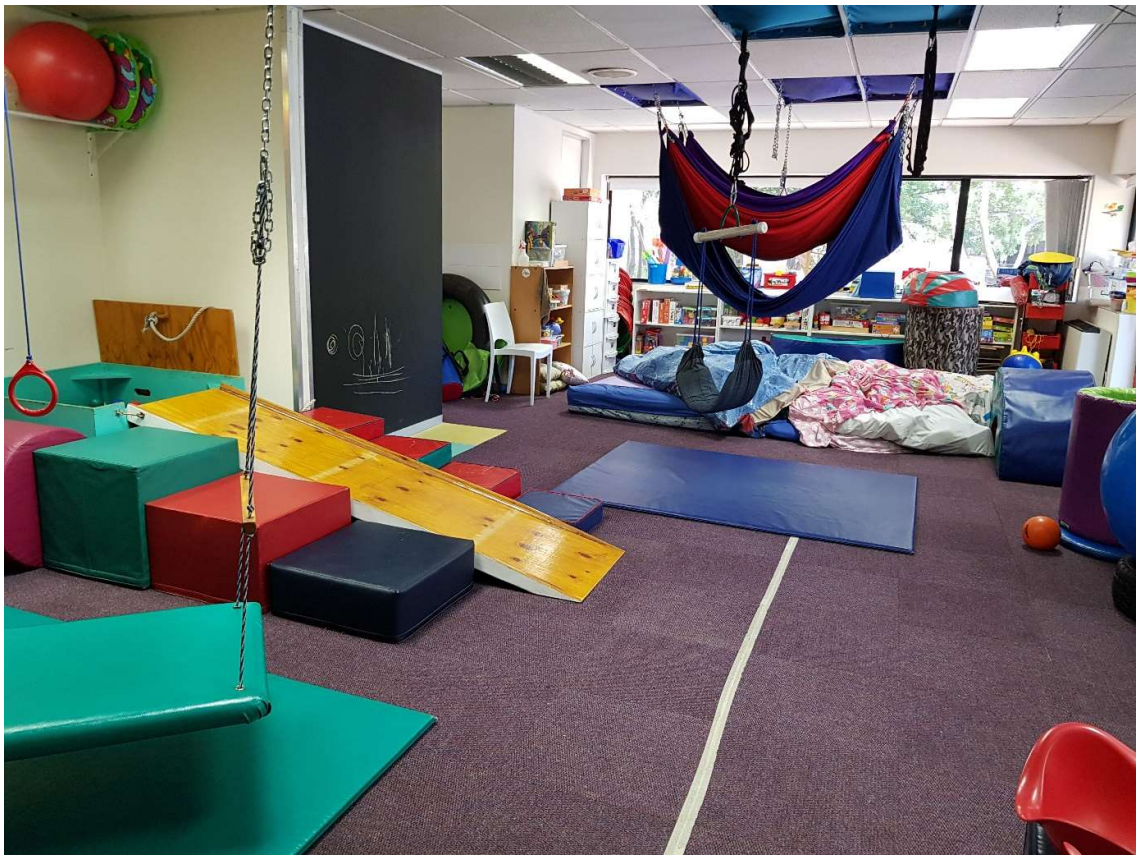


Figure 3.6 : Occupational therapy room with equipment used to provide Routine Sensory Integration Based Occupational Therapy.

3.4.2 The Astronaut Training Protocol (Appendix I)

The Astronaut Training was implemented by following the guidelines (steps) in the Astronaut Training Protocol booklet, starting with the preparatory exercises to stimulate the vestibular system and midline crossing, then moving to the rotatory and eye movement exercises as step two. This was done by rotating the participant on the Astronaut Training board to the specific music track, in sitting and side lying on the left and right sides. The rotation was followed by eye movements (horizontal saccades and smooth pursuits) in sitting and vertical eye movements in side lying. Step three then involved the eye movement wrap up where all eye movements are used in combination, including convergence and divergence. Step four was activities to

activate the core muscles (Kawar, et al., 2005). Linear vestibular activities were chosen from the Astronaut Training Protocol and other activities were consulted with Mary Kawar specifically to target the core muscles of flexion and extension needed for sitting at the table. Prone extension activities included:

- lying in prone on a scooter board and pushing off a wall with their hands;
- lying in prone on a scooter board and holding a bungee cord attached to the wall in order to pull forwards and backwards whilst looking at visual targets on the floor;
- lying in prone in a hammock with the hammock positioned under the armpits and mid-thigh, swinging to fetch beanbags placed on the floor to then throw to a target about two meters away.

Supine flexion was stimulated by:

- lying in supine on a scooter board and kicking off a wall;
- lying in supine on a scooter board and pulling a bungee cord to move their body forward and backwards;
- lying in supine in the hammock with the hammock positioned from the scapulae to the mid-thigh with beanbags placed on the stomach leading the child to flex the neck in order to aim and throw beanbags at a target.

The occupational therapist implementing the Astronaut Training Protocol was certified in implementing the programme which was obtained by attending the course hosted by Mary Kawar in South Africa in 2015. Treatment notes were kept on each child to document their progress such as tolerance for rotation and any side effects experienced (Appendix J). According to Kawar et al (2005), the Astronaut Training Protocol should be done at the beginning of a therapy session to activate the sensory systems. Rotary input should be gradually increased according to the child's tolerance and should be done twice per day. The frequency of using the programme should then be decreased. If a regression (in posture, balance, eye movements, vestibular tolerance etc) is noted when the programme has been stopped, then it should be re-

implemented and can be made to be part of a child's maintenance programme indefinitely. The therapist can train teachers or caregivers to use this programme at home on a daily basis under the careful guidance of an occupational therapist (Kawar, et al., 2005). Implementing the programme twice per day was not viable for this research and therefore it was chosen to do it over eight sessions.

The Astronaut Training Protocol was included and implemented at the start of each of the sensory integration based occupational therapy sessions as recommended by Kawar et al (2005). Attempts were made to do additional Astronaut Training sessions twice to three times per week. This was done to attempt to use the intensity suggested by Kawar et al (2005). The extra Astronaut Training sessions were arranged and done at a place convenient to parents such as at school or at home. The intensity of the programme depended on parents' and children's schedules and therefore it was not viable to do the eight sessions over a consistent time period. These sessions were either done intensely (over three weeks i.e. two to three times per week) or with less intensity (over seven weeks i.e. approximately once per week). However, each participant still received the required eight sessions of Astronaut Training whilst keeping their regular occupational therapy sessions consistent.

3.5 Research procedure

Once ethical clearance had been received from the Research Ethics Committee at the University of the Witwatersrand (M 170522) (Appendix M) and permission granted from the practice to recruit participants (Appendix A), the researching occupational therapist began to identify suitable candidates from her caseload for the study (Appendix B). Parents were then contacted either in person or telephonically to explain the study. An information document was emailed to parents further explaining the study which also included informed consent to participate and to be videoed as well as a brief background questionnaire to be completed on their child (Appendix K). Finally, parents were asked to sign the forms and to return them in person or via email. The research was explained to the participant face-to-face with accompanying visuals illustrating the

Astronaut Training Programme. The participant signed informed assent to participate in the study and informed assent be videoed (Appendix L) – this was witnessed and signed by another adult. It was made clear to parents and participants that withdrawal from the study at any time was possible with no negative effects.

The researcher performed the sensory integration based occupational therapy sessions throughout the research and the Astronaut Training sessions. This allowed for consistency of therapy style. She was qualified in Ayres Sensory Integration and attended the Astronaut Training Protocol course. She also conducted the posture and accelerometer assessments and videoed the supine flexion and prone extension positions assessments at the end of each therapy session. When possible, occupational therapists, trained in the administration of the Sensory Integration and Praxis Test, from the private practice administered and recorded the scores of the balance and PRN assessment. This was done at the start of the occupational therapy sessions. However, this was not always viable as therapists working hours changed due to the nature of working in private practice. Analysis of the balance, PRN, posture and accelerometer assessments were done by the researcher. The supine flexion and prone extension scoring were done by the researcher and research assistant by analysing the videos (See Table 3.1).

Table 3.1 Roles of individual's involved in research procedure

		Researcher	OTs at practice	Research assistant
Implementation of assessment	Assess balance, PRN		x	
	Video in-seat posture & in-seat movement	x		
	Video supine flexion & prone extension	x		
Analysis of assessment	Balance. PRN (converting raw scores to standard scores)	x		
	Scoring in-seat posture and in-seat movement from video and accelerometer	x		
	Scoring Prone extension and supine flexion from shuffled videos	x		x
Treatment	Sensory integration based therapy	x		
	Astronaut Training	x		

3.5.1 Data collection

Data for each participant was collected over the 16 sessions in three phases. Number of treatment sessions instead of a number of weeks were used as the research took place at a private practice. School holidays, public holidays or children being absent impacted on the consistency of therapy attendance. Some participants, therefore,

attended therapy twice per week to make-up missed sessions resulting in some weeks having more therapy sessions. The following subtests were used to measure the participant's vestibular processing at sessions one, four, 13 and 16, as well as at the start and the end of the Baseline (A), Intervention (B) and Withdrawal (A) phases. These assessments were conducted by an experienced and independent occupational therapist, where possible, to prevent any assessor's bias.

3.5.1.1 Phase A: Baseline

The participant underwent the *pre-test assessments* (one-leg balance, PRN, in-seat posture and in-seat movement assessments) at the start of the Baseline phase (A) i.e. during session one. Between therapy session one and session four, which made up the Baseline phase, the participant attended their regular sensory integration based occupational therapy sessions. At the end of each therapy session, the *repeated measure assessments* (supine flexion position and prone extension position) were administered.

3.5.1.2 Phase B: Intervention

The participant underwent the *pre-test assessments* (one-leg balance, PRN, in-seat posture and in-seat movement assessments) at the start (session four).

The participants' ability to tolerate rotary input was assessed before Astronaut Training started, though the PRN Test and the number of rotations they could tolerate over the course of Astronaut Training was noted to prevent any overstimulation (Table 3.2). The full programme has 60 rotations. Progress notes (Appendix J) were kept on each participant to record the number of rotations they could tolerate in the session, whether there were any side effects to the rotation and the quality of motor output. This guided the amount of rotation used in the Astronaut Training. Precautions were put in place to ensure the child's vestibular system did not get overstimulated. Sympathetic

nervous system signs such as flushing, going pale, increased breathing or heart rate, sweaty hands or feeling nauseous indicate overstimulation and were counteracted with proprioceptive activities or applying ice to the palms of the hands, temples of the head and behind the neck (Kawar, et al., 2005). Proprioceptive activities have an inhibiting effect on the vestibular system (Fredrickson, et al., 1966).

Table 3.2 Participants toleration of rotary input

Participant	Tolerates / over-reactive to rotary input	Number of rotations can tolerate over course of Astronaut Training
M001	Over-reactive	2-4
M002	Tolerates	24-60
M003	Tolerates	28-54
M004	Over-reactive	18-41
M005	Tolerates	30-54

Astronaut Training sessions took place over a four-eight week period and each session was approximately 15-25 minutes. The participant underwent eight sessions of the Astronaut Training Protocol. This was done once to three times per week at a time convenient to the participant, either at school or at the aforementioned private practice. Table 3.3 indicates how many weeks Astronaut Training took place for each participant.

Table 3.3 Weeks over which Astronaut Training took place

Participant	Number of weeks Astronaut Training took place
M001	3 weeks
M002	6 weeks
M003	7 weeks
M004	3 weeks
M005	5 weeks

At the end of each Astronaut Training session, the repeated measure assessments were done (prone extension position and supine flexion position). The participant continued with their usual occupational therapy schedule with no additional assessments.

3.5.1.3 Phase C: Withdrawal

The participant underwent the *post-test assessments* (one-leg balance, PRN, in-seat posture and in-seat movement assessments) at the start of the Withdrawal phase i.e. session 13 and end of the Withdrawal phase (A) i.e. session 16. The participant had their regular sensory integration based occupational therapy without the Astronaut Training Protocol. At the end of each therapy session, the repeated measure assessments were done (prone extension position and supine flexion position). Withdrawal assessments were planned to be done approximately four weeks post Astronaut Training. Due to unforeseen circumstances such as holidays and conflicting schedules, two of the withdrawal assessments were done delayed at 11 to 13 weeks post Astronaut Training.

Figure 3.7 shows the research process with table 3.4 indicating the time period that research took place for each participant.

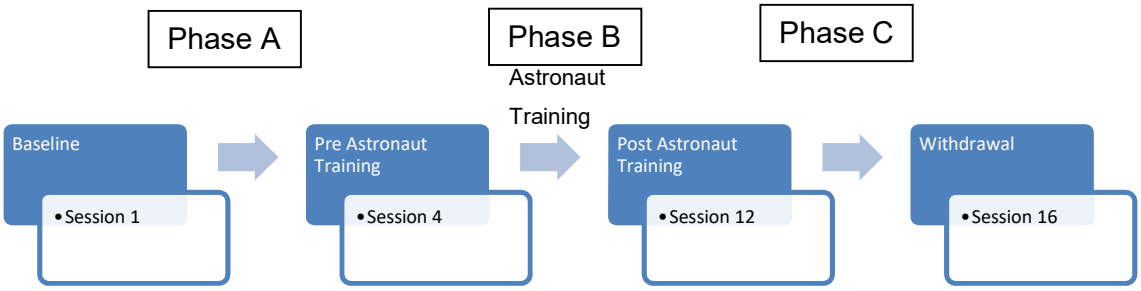


Figure 3.7 Diagram to show the phases of the research process

Table 3.4 Table to show the number of weeks research took place for each participant

	Baseline	**Pre Astronaut Training**	**Astronaut Training**	**Post Astronaut Training**	**Withdrawal**
	Session 1	**Session 4**	**Session 5-12**	**Session 13**	**Session 16**
M001	Week 1	Week 5	Week 6 - 8	Week 8	Week 12
M002	Week 1	Week 3	Week 4 - 9	Week 10	Week 13
M003	Week 1	Week 4	Week 5 - 11	Week 15	Week 24
M004	Week 1	Week 4	Week 5 - 7	Week 8	Week 12
M005	Week 1	Week 5	Week 9 - 13	Week 17	Week 24

3.5.2 Data scoring of supine flexion and prone extension positions

The videoed assessments were scored by two occupational therapists with over five years of' paediatric experience to prevent assessor's bias. Videos were assigned a random number and the order shuffled to further prevent experimenter's bias. Scores were compared for each video and discussed between the two occupational therapists to ensure the accuracy of scoring.

3.5.3 Variables

The independent variable was the Astronaut Training Protocol. The dependent variables were vestibular function and postural control related to in-seat movement, in-seat posture, balance, and assuming anti-gravity positions of prone extension and supine flexion. The control variable was regular sensory integration based occupational therapy sessions as this was kept consistent throughout the study.

3.6 Data analysis

Data was analysed through descriptive statistics and single subject statistics. Demographics of age, gender and taking medication for concentration was analysed as nominal data, whilst tolerance for rotational input was analysed as interval data.

Data was captured as the following:

- Balance: time was recorded in seconds and then converted to a standard score as per the Movement ABC-2 manual and then z scores
- PRN: time was recorded in seconds and then converted to z scores as per the Sensory Integration and Praxis Test computerised programme.
- In-seat posture: raw scores were used as this was not a standardised assessment with standard scores.
- In-seat movement: raw scores were used.

- Prone extension and supine flexion positions: There were two scores recorded: quality and time. Raw quality scores were tallied on each assessment based on the scoring criteria. Time in seconds was used.

Four pre-test, post-test assessments were used to collect data over four periods: Baseline, pre-Astronaut Training, post-Astronaut Training and Withdrawal of the intervention programme. Only Pre-Astronaut Training scores were used as this was thought to be a more accurate reflection of the participants vestibular and postural control scores pre-Astronaut Training (A). This was compared to the post-Astronaut Training phase (B) and the Withdrawal phase (A). These assessments related to vestibular processing of the Postrotary Nystagmus test and balance test, as well as postural control assessments of in-seat movement through the use of an accelerometer and in-seat posture through observation checklist. This data was ordinal and interval but was analysed as non-parametric due to the small sample size and the fact that data was not normally distributed.

Medians and lower and upper quartiles were analysed. The Wilcoxon sign-ranked test was used to measure the change in the median scores of the small sample size and obtain the p values and Cohen's r to obtain effect size. The effect size was used to analyse the clinical significance of the change in the data (Busk & Serlin, 1992). It was used as it indicated the amount of change between the various phases of the research (Parker, et al., 2009), whereas the p-value analysed the statistically significant change.

The repeated measures of supine flexion and prone extension, as indicated, were done at each therapy session over the 16 sessions. The repeated measure tests were analysed separately as it was a single subject research design. Visual graphs were used to measure the change over the three phases of the study and improvement rate scores for these three phases were determined. Improvement rate was used to compare the performance between Baseline (A) and Intervention phase (B), and then between Intervention (B) and Withdrawal (A) to determine whether the intervention was successful.

Improvement rate was calculated from the visual analysis of the line graphs. This was done for quality and time scores. The number of improved data points (compared to the previous phase) were circled, added and then divided by the total number of data points for that particular phase. This was then converted to a percentage. Large variations in data points did not impact on the overall outcomes as any improvement point no matter how large or small was compared to the highest data point of the previous phase. The same was done to see if there was a deterioration by comparing the lower scores in that phase to the previous phase and dividing by the total number of data points in that particular phase (Parker, et al., 2009). The total improvement rate between pre-Astronaut Training and Withdrawal (A-A) was obtained by the addition of the improvement rate pre and post-Astronaut Training (A-B) to post-Astronaut Training and Withdrawal (B-A).

3.7 Ethical considerations

As previously stated, ethical clearance for the study was obtained from the Research Ethics Committee at the University of the Witwatersrand (M 170522) (Appendix M) in addition to permission to complete the study being received from the private occupational therapy practice (Appendix A). As previously explained, parents of participants received an information sheet and were asked to sign an informed consent in order for their child to participate (and be video recorded – see Appendix K).In addition, informed assent to take part in the study and to be videoed was signed by each individual child (Appendix L). Parents and children were told that participation was completely voluntary and that withdrawal at any time during the study was possible, with no negative consequences. Following the completion of the study, written progress on the intervention was shared with parents via email, as well as research findings.

Confidentiality was ensured by providing each participant with a code and keeping participant and parent details in a separate location to the codes. Video cameras were locked in a room when not in use and saved on a password-protected laptop. Videos

and data will be kept for six years post-research according to the Health Professionals Council of South Africa (HPCSA) guidelines at which point all data will then be destroyed.

As stated, the research took place in a private occupational therapy practice. Parents were responsible for paying for regular occupational therapy sessions and claiming back from their medical aid. Regular occupational therapy sessions were charged for however the extra Astronaut Training sessions were not (i.e. when extra Astronaut Training sessions were done at home or at school). As this was the additional intervention for the research. Assessments that were chosen for the research (balance, PRN, supine flexion and prone extension) were quick to administer and did not take up their paid occupational therapy time. These were done during an additional five minutes following their therapy time. The 10-minute table-top assessment took place during paid therapy time. A 10 to 20 table-top activity is done in therapy sessions to work on fine motor and visual perceptual skills.

CHAPTER 4: RESULTS

4.1 Introduction

Five participants were used in a three-phase single subject study. A convenient sample was used from one private paediatric occupational therapy practice in Johannesburg. Children who displayed poor table-top posture, fidgeting or slouching, and displayed poor supine flexion and prone extension scores were included in the study. The Astronaut Training Protocol was used as the intervention to determine the change in vestibular processing and postural control in in-seat posture and in-seat movement. All participants remained in the study for the duration of the data collection period although there was missing data due to some participants refusing to participate during certain assessments. Some data were also collected at inconsistent times as two participants were not able to keep to their last appointments and had to wait five to 13 weeks before attending their final session.

4.2 Demographics

Participants ranged from five years three months to six years four months, four of which were male and one of which was female. All participants were white, attend various private schools in Johannesburg, as well as occupational therapy sessions with the same therapist at the private practice where the study was conducted (Table 4.1). None of the participants were on medication for their concentration during the study except participant M003 who started medication during the Withdrawal phase (A).

Table 4.1 Demographics of the sample

Parti-cipant	Gender	Age at Baseline and at withdrawal	On concentration medication during research?	Number of weeks research took place	Number of week Astronaut Training took place	Over-reactive to rotation
M001	Male	5 yr 8 m- 5 yr 11 m	No	12 weeks	3 weeks	Yes
M002	Male	5 yr 3 m- 5 yr 6 m	No	12 weeks	6 weeks	No
M003	Female	5 yr 5 m- 5 yr 10 m	Started during Withdrawal	23 weeks	7 weeks	No
M004	Male	6 yr 1 m- 6 yr 4 m	No	11 weeks	3 weeks	Yes
M005	Male	5 yr 9 m- 6 yr 3 m	No	23 weeks	5 weeks	No

4.3 Baseline and Pre-Astronaut Training

Baseline and pre-Astronaut Training scores were compared. Scores got worse from Baseline to pre-Astronaut Training in all areas with a medium to large effect size except for in-seat posture which improved (see Table 4.2). This difference appeared to be due to the participants' poor motivation during assessments. It was decided to only compare the intervention of the Astronaut Training Protocol with the pre-Astronaut Training phase due to this large variability.

Table 4.2 Comparison of baseline and pre-Astronaut Training scores

		Baseline	Pre-Astronaut Training	Difference Baseline to Pre-Astronaut	p-value	Effect size Cohen's r
Balance z scores	M001	0.35	-0.7	-1.05	0.354	-0.42*
	M002	-0.7	-1	-0.3		
	M003	-0.7	-0.35	0.35		
	M004	-1.6	-1.75	-0.15		
	M005	-0.7	-1	-0.3		
PRN z scores	M001	-1.31	0.56	1.87	0.500	-0.30*
	M002	-0.08	-0.74	-0.66		
	M003	0.05	-0.22	-0.27		
	M004	0.59	0.18	-0.41		
	M005	1.84	1.49	-0.35		
In seat posture	M001	9.5	0.56	-2.75	0.093	0.63**
	M002	9.5	7	-2.5		
	M003	9.5	3.5	-6		
	M004	7.5	6.5	-1		
	M005	4	1	-3		
In seat movement - Accelerometer vector magnitude	M001	2777.94	1652.18	-1125.76	0,224	-0.54**
	M002	1708.91	3828.47	2119.56		
	M003	3266.69	4270.45	1003.76		
	M004	5660.83	11513.37	5852.54		
	M005	374.21	531.88	157.67		

Significant at p <,05*

Large effect size = 0.5**
Medium effect size = 0.3*
Small effect size = 0.1

4.4 Pre and Post Intervention Assessments

Pre and post-Astronaut Training scores were compared to determine the change following the intervention of the Astronaut Training Protocol.

Analysis was completed using three scores for all pre and post-intervention assessments which were the pre-Astronaut Training (A), the post- Astronaut Training (B) (i.e. the intervention phase) and the Withdrawal scores (A).

4.4.1 Vestibular function

This section will discuss the data for the balance test and Postrotary Nystagmus test as these tests infer information relating to vestibular functioning. These were compared post-Astronaut Training and after four sessions of withdrawal from the Astronaut Training Protocol.

4.4.1.1 Balance

Post-Astronaut Training

One-leg balance z scores falling between -1 and +1 standard deviations are within the typical range for three participants, with participant M004 having a score greater than -1.5, indicting dysfunction at pre and post-Astronaut Training. Participant M001's balance scores were worse than at Pre Astronaut Training, with a score of below -1.5 post-Astronaut training while all other participants improved post-Astronaut Training (B).

Withdrawal

At Withdrawal (A), M001 showed improvement and the score at Withdrawal (A) was slightly improved to that at pre-Astronaut Training (A). M002 was the only participant to show improvement in balance over the three phases, whereas M004 and M005 showed no further improvement on Withdrawal (A). M003's balance score was also lower at Withdrawal than at pre-Astronaut Training (A) and post-Astronaut Training (B). Therefore, for most participants, balance was seen to improve post-Astronaut Training (B) and Withdrawal (A).

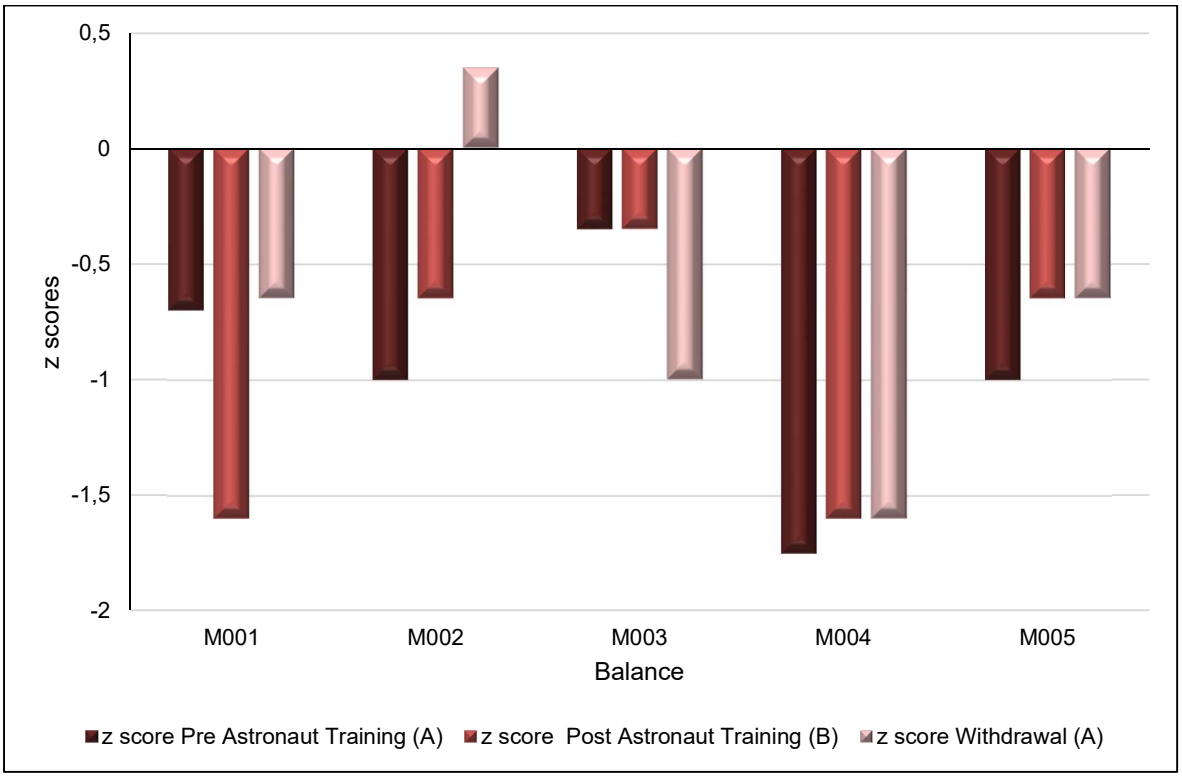


Figure 4.1 Balance z scores for each participant (n=5)

Table 4.2 indicates that balance improved with a small effect size from pre-Astronaut Training (A) to post- Astronaut Training (B). Balance scores continued to improve between post-Astronaut Training (B) and Withdrawal (A) with a medium effect size of 0.41. Therefore, a small improvement in balance for most participants was seen to occur during the Astronaut Training phase (B), with further improvement at the Withdrawal phase (A).

Table 4.3 Combined Balance z scores at Pre-Astronaut Training (A), Post-Astronaut Training (B) and Withdrawal (A)

Balance	Median (Lower Quartile and Upper Quartile)	Difference in Median Scores		p-value	Effect size Cohen's r
Pre-Astronaut Training(A)	-1,00 (-1.00 - -0.70)	Pre-astronaut Training vs post-Astronaut Training (A-B)	-0.25	0.715	0.16
Post-Astronaut Training (B)	-0.75 (-1.60:-0.70)				
Withdrawal (A)	-0.65 (-1.00:-0.65)	Post-Astronaut Training vs Withdrawal (B-A)	-0.10	0.372	0.41*

Significant at p <,05*

Large effect size = 0.5**
Medium effect size = 0.3*
Small effect size = 0.1

4.3.1.2 Postrotary Nystagmus

Post-Astronaut Training

Postrotary Nystagmus (PRN) z scores that fell between -1 and +1 standard deviation are within the typical range. Participants M001, M002, M003 and M004 continued to score within the average range post-Astronaut Training with M002 and M004 showing improvements with scores tending towards zero. M005 showed improvements in PRN, however, this was still not within the typical range. M001's score did not change and the score of M003 was lower but stayed within the average range post-intervention.

Withdrawal

Postrotary Nystagmus scores remained within the average range for all participants except M005. He started with a score higher than +1 standard deviation indicating that inhibition from higher cortical areas was poor. His PRN score came down during intervention but again increased following Withdrawal. His score may have been

higher at Withdrawal due to having had a five week break from therapy before the Withdrawal reassessment.

M002, M003 and M005 could tolerate rotational input without displaying signs of over-reactivity. M002 and M003 showed improvements in PRN and remained within the average range (Figure 4.2). Although M001 and M004 displayed signs of overstimulation to rotational input during the Astronaut Training Protocol, their PRN scores were within the average range throughout the assessments.

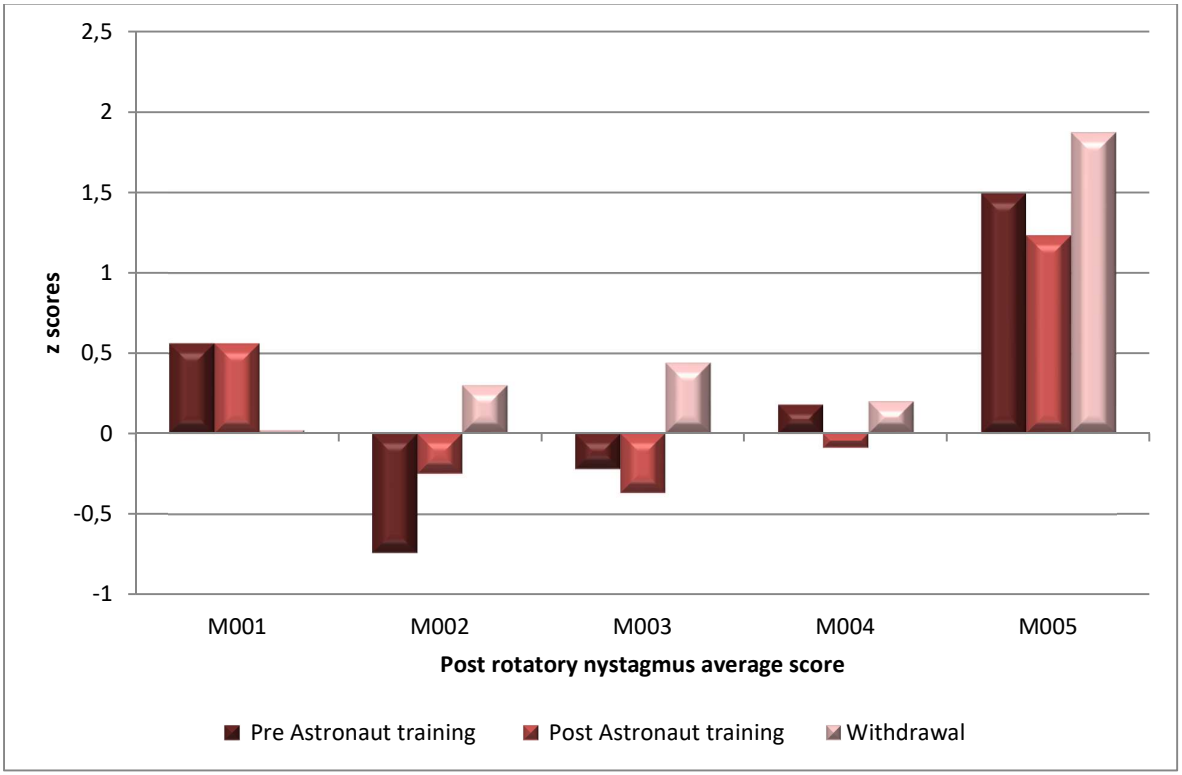


Figure 4.2 Postrotary Nystagmus z scores for each participant (n=5)

When the z scores for PRN were compared for pre and post-Astronaut Training (A-B), there was no significant change with the effect size showing a small decrease in the scores. Although it was not a statistically significant difference between the post-

Astronaut Training (B) and Withdrawal (A), the effect size of 0.66 was large, indicating a clinical change in PRN in this phase (Table 4.3).

Table 4.4 Combined Postrotary Nystagmus z scores at Pre-Astronaut Training (A), Post-Astronaut Training (B) and Withdrawal (A) (n=5)

Postrotary Nystagmus	Median (Lower Quartile and Upper Quartile)	Difference in Median Scores		p-value	Effect size Cohen's r
Pre-Astronaut Training (A)	0.18 (-0.22:0.56)	Pre-astronaut Training vs post-Astronaut Training (A-B)	-0.27	0.715	-0.16
Post-Astronaut Training (B)	-0.09 (-0.25:0.56)				
Withdrawal (A)	0.30 (0.20:0.44)	Post-Astronaut Training vs Withdrawal (B-A)	0.39	0.138	0.66**

Significant at p <,05*

Large effect size = 0.5**
Medium effect size = 0.3*
Small effect size = 0.1

Summary of vestibular function results

Improvements in vestibular function were evident at withdrawal due to the medium and large effect size in balance and PRN respectively, indicating a clinical change in vestibular function although not a statistically significant difference.

4.4.2 Postural control

Changes in postural control were analysed post-Astronaut Training (B) and after Withdrawal (A). In-seat posture and in-seat movement were also analysed.

4.4.2.1 In-seat posture

In-seat posture was measured by videoing the participant with analyses taking place at 7.30 minutes (posture 1) and 9.30 minutes (posture 2). Since the results for the two posture assessments were similar, they were combined for in-seat posture.

Post-Astronaut Training

Scores closer to zero indicate better posture, indicating that all participants improved post-Astronaut Training (B).

Withdrawal

The posture of participants (M002, M003 and M005), who could tolerate rotatory input at the start of the study, deteriorated during the Withdrawal phase (A), while the posture of participants M001 and M004 continued to improve. However, the posture of all participants was better than that assessed at the pre-Astronaut Training (A) after Withdrawal (Figure 4.3).

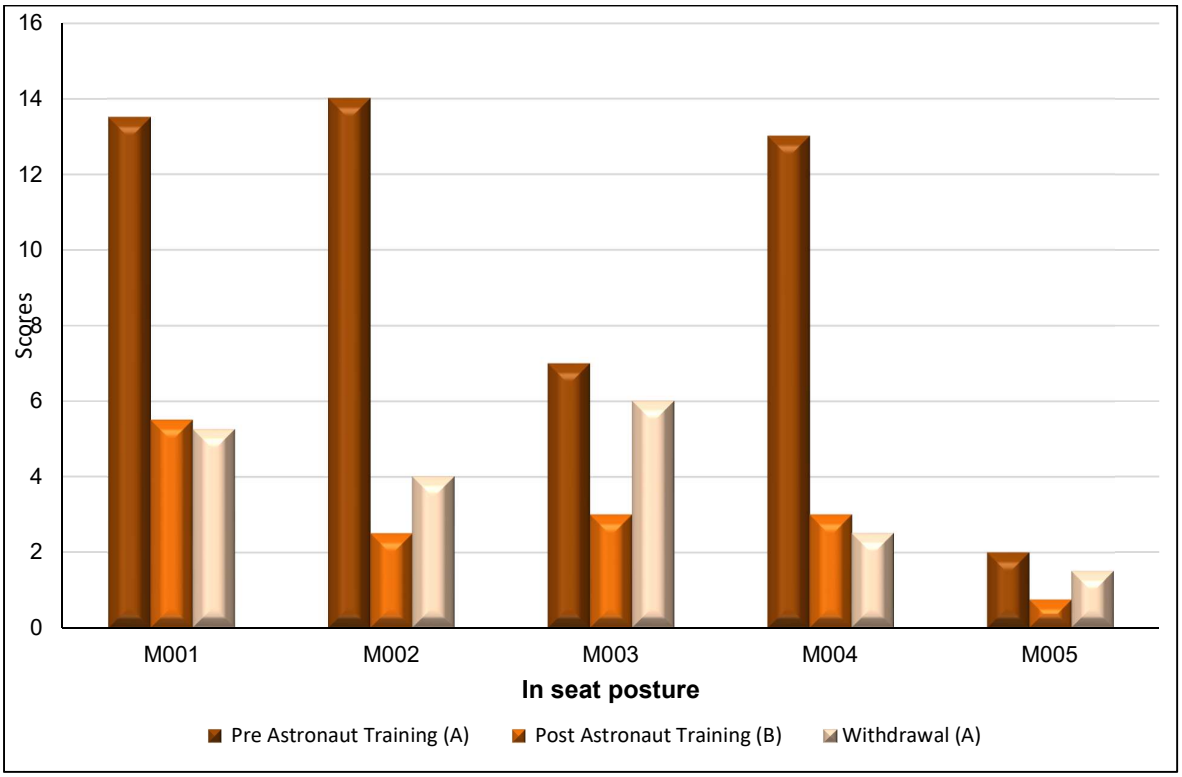


Figure 4.3 In-seat posture scores for each participant (n=5)

There was a statistically significant improvement in posture between pre-Astronaut Training (A) and post-Astronaut Training (B). The large effect size (0.90) indicates this change had clinical significance as well at statistical significance ($p<0.05$) during the Intervention phase (B). The posture scores were higher for the change between post-Astronaut Training (B) and Withdrawal (A). The effect size at Withdrawal (A) was -0.54, indicating posture was not maintained at Withdrawal phase (A) (Table 4.4).

Table 4.5 Combined Posture scores at Pre-Astronaut Training (A), Post-Astronaut Training (B) and Withdrawal (A) (n=5)

Posture	Median (Lower Quartile and Upper Quartile)	Difference in Median Scores		p-value	Effect size Cohen's r
Pre-Astronaut Training(A)	13.00 (7.00 - 13.5)	Pre-astronaut Training vs post-Astronaut Training (A-B)	10.00	0.043*	0.90**
Post-Astronaut Training (B)	3.00 (2.50-3.00)				
Withdrawal (A)	4.00 (2.50-5.25)	Post-Astronaut Training vs Withdrawal (B-A)	1.00	0.224	-0.54**

Significant at p <,05*

Large effect size = 0.5**
Medium effect size = 0.3*
Small effect size = 0.1

4.4.2.2 In-seat movement

Post-Astronaut Training

The scores from the Actigraph Accelerometer vector magnitude were used to analyse overall fidgety movements (Figure 4.4). A lower score indicates less in-seat movement and this was found for all participants at post-Astronaut Training (B), except for M001, and M005 who presented with very little movement at pre- Astronaut Training (A) and still had more yet little movement post-Astronaut Training (B).

Withdrawal

Less in-seat movement was observed after the Withdrawal phase (A) in M001 and M004 who were the participants over-reactive to rotatory input at the start of the study. The remaining participants all displayed an increase in in-seat movement at Withdrawal (A), with that for M003 and M005, who were inconsistent in their

attendance during withdrawal phase, increasing to a higher score than that for their pre-Astronaut Training (A) score (Figure 4.4)

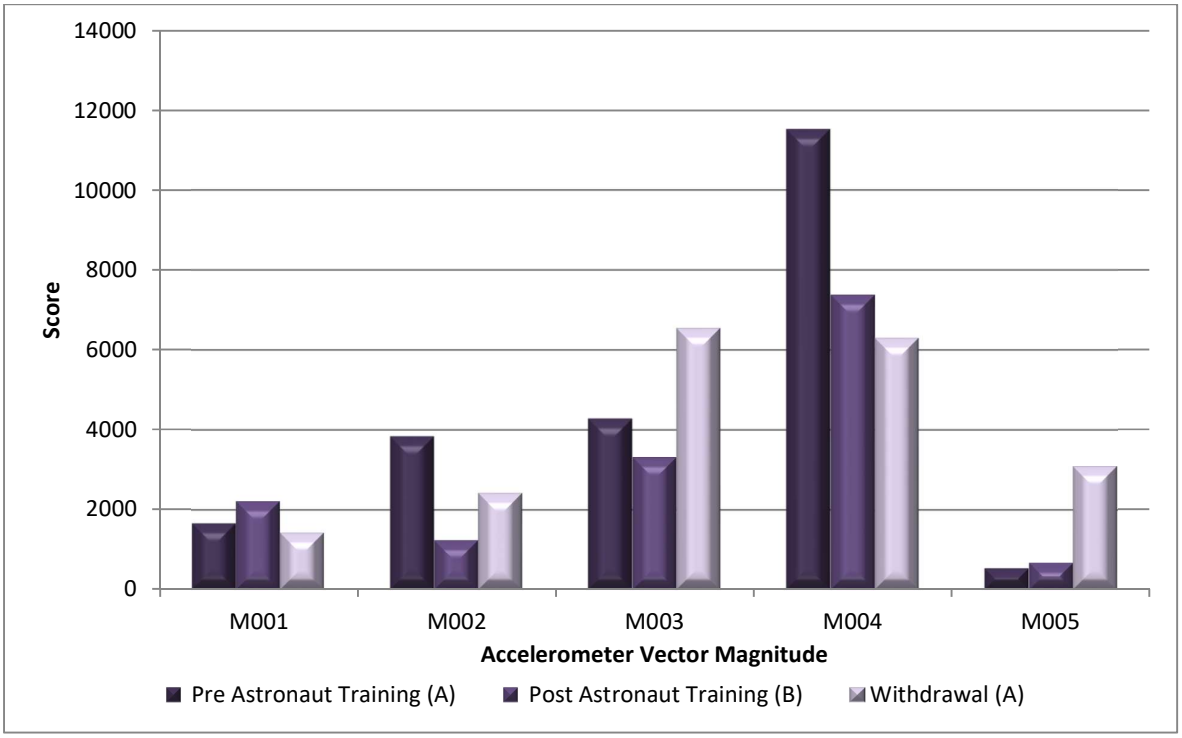


Figure 4.4 Accelerometer Vector magnitude in-seat movement scores for each participant (n=5)

No statistically significant difference was found for vector magnitude between the pre-Astronaut Training (A) and post-Astronaut Training (B), however, there was a large clinical difference in the effect size (0.59), indicating a clinical reduction in in-seat movement during the Intervention phase (B). The difference between the post-Astronaut Training (B) and the Withdrawal phase (A) was also not statistically significant, but the in-seat movement increased with a large-effect size (-0.54) which indicated gains made in the Intervention phase (B) were not retained when the intervention was withdrawn (A) for most participants (Table 4.6).

Table 4.6 Combined Accelerometer Vector magnitude in-seat movement scores at Baseline and Pre-Astronaut Training (A), Post-Astronaut Training (B) and Withdrawal (A) (n=5)

Accelerometer Vector magnitude	Median (Lower Quartile and Upper Quartile)	Difference in Median Scores		p-value	Effect size Cohen's r
Pre-Astronaut Training(A)	3828,47 (1652,18 - 4270,45)	Pre-astronaut Training vs post-Astronaut Training (A-B)	-1616.45	0.224	0.59**
Post-Astronaut Training (B)	2212.02 (1242.17:- 3316.16)				
Withdrawal (A)	3086.87 (2414.16: 6287.73)	Post-Astronaut Training vs Withdrawal (B-A)	847.85	0.224	-0.54**

Significant at p <,05*

Large effect size = 0.5**
Medium effect size = 0.3*
Small effect size = 0.1

Summary of postural control results

Postural control improved post Astronaut Training with a large effect size and significant difference in in-seat posture, and a large effect size on in-seat movement. Postural control was not maintained and decreased at the Withdrawal phase.

Table 4.7 shows a summary of improvement, decline or staying the same during the assessments for all participants over the phases of the study. A similarity can be seen in M002 and M003 showing improvements post Astronaut Training. With M001 and M004 showing more improvements at withdrawal.

Table 4.7 Summary of improvement and decrease in Balance, PRN, In-seat Posture and In-seat Movement assessment scores

	M001		M002		M003		M004		M005	
	Post AT	With-drawal	Post AT	With-drawal	Post AT	With-drawal	Post AT	With-drawal	Post AT	With-drawal
Balance	-	+	+	+	=	-----	+	=	+	=
PRN	=	+	+	+	-	+	-	+	+	------
In-seat Posture	+	+	+	-	+	-	+	+	+	-
In-seat Movement	-	+	+	-	+	-	+	+	-	-----

Key:		
	+	Improved
	-	Decreased
	------	Decreased more than pre-Astronaut Training phase
	=	Stayed the same

4.5 Repeated measures

To analyse the repeated measures three phases were used:

- Pre-Astronaut Training (A)- this comprised of the four repeated measure assessments of prone extension and supine flexion between baseline and pre-Astronaut Training intervention.
- Post-Astronaut Training (B)- this comprised of the eight repeated measure assessments of prone extension and supine flexion over the course of the eight Astronaut Training intervention sessions
- Withdrawal (A)- this comprised of the four repeated measure assessments of prone extension and supine flexion during the withdrawal of Astronaut Training intervention.

Changes in the repeated measures were compared between pre-Astronaut Training and post Astronaut Training (A-B) to determine change during the intervention of the Astronaut Training Protocol. Post-Astronaut Training and Withdrawal (B-A) were

compared to determine change when Astronaut Training was withdrawn. The total change was then determined to compare pre-Astronaut Training to Withdrawal (A-A)

4.5.1 Prone extension quality

The quality and the time for which the prone extension position could be held was assessed at every occupational therapy session. Figure 4.5 shows the line graph of prone extension quality between the phases of the study for each participant.

Pre-Astronaut Training to Post-Astronaut Training (A-B)

Quality was assessed via an observational checklist adapted for this research. Improvement in quality was 50% or less between the pre-Astronaut Training (A) and post-Astronaut Training (B) for participants M001 and M003 (Table 4.7). The other participants showed a decrease in the quality of prone extension, except for M002 where there was no change (Table 4.8: Figure 4.5).

Table 4.8: Table to show the improvement rate percentage in quality of prone extension between pre-Astronaut Training (A), post-Astronaut Training (B) and Withdrawal (A)

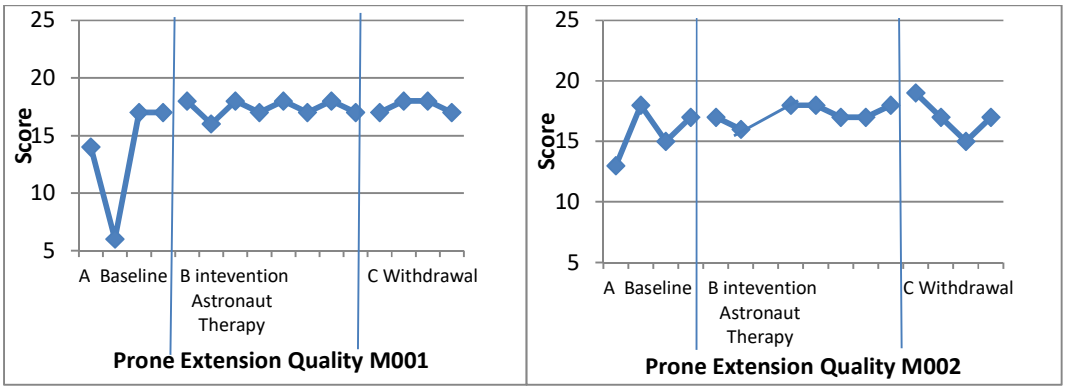
	Improvement rate between pre-AT and post-AT (A-B)	Improvement rate between post-AT and Withdrawal AT (B-A)	Total Improvement rate between pre-Astronaut Training and Withdrawal (A-A)
M001	50,00	0,00	50,00
M002	0,00	0,00	0,00
M003	42,68	25,00	67,68
M004	-50,00	0,00	-50,00
M005	-71,43	75,00	3,57

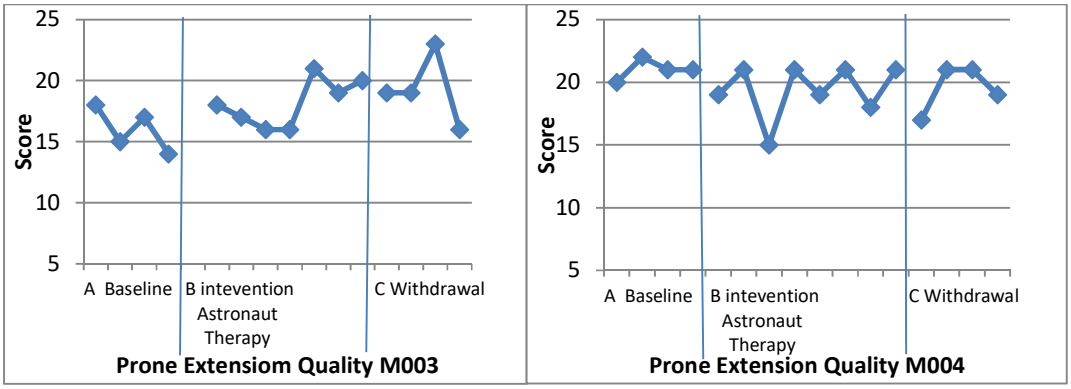
Post-Astronaut Training to Withdrawal (B-A)

The improvement between post-Astronaut Training (B) and Withdrawal (A) was 25% for participant M003 and 75% for M005. Only participant M003 was found to have an improvement in prone extension in the Intervention phase (B) and during Withdrawal

(A). M002 did not show any change in prone extension quality over the phases with the quality remaining consistent.

Overall, M001 and M003 showed an over 50% improvement rate between pre-Astronaut Training (A) and Withdrawal (A), with M005 showing a small improvement and M004 showing a 50% deterioration (Table 4.8: Figure 4.5).





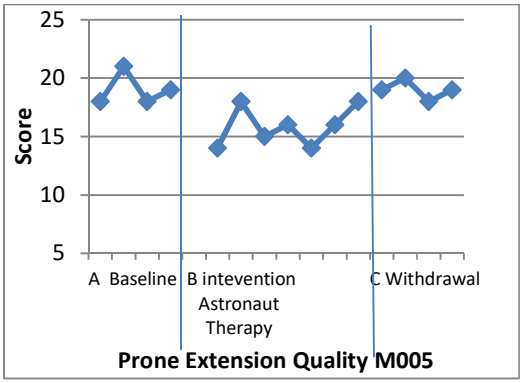


Figure 4.5 Scores for the quality of prone extension at Baseline and Pre-Astronaut Training (A), Post-Astronaut Training (B) and Withdrawal (A) for each participant (n=5)

4.5.2 Prone extension time

Figure 4.6 shows the line graph of prone extension time duration throughout the phases of the study for each participant with Table 4.9 showing the improvement rate percentage between the phases.

Pre-Astronaut Training to Post-Astronaut Training (A-B)

Improvements in the time the position of prone extension of less than 50% was held were seen in participants M001 and M003 between the pre-Astronaut Training (A) and post-Astronaut Training (B), whereas M005 displayed an 85.71% decrease in time. Participants M002 and M004 had an increase in time that was greater than 50% (Table 4.9: Figure 4.6)

Table 4.9: Table to show the improvement rate percentage in time of prone extension between pre-Astronaut Training (A), post-Astronaut Training (B) and Withdrawal (A)

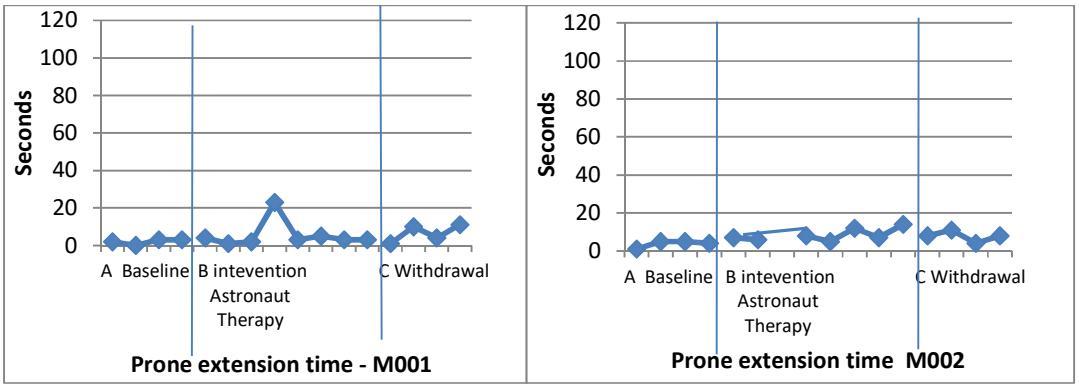
	Improvement rate between pre-AT and post-AT (A-B)	Improvement rate between post-AT and Withdrawal AT (B-A)	Total Improvement rate between pre-Astronaut Training and Withdrawal (A-A)
M001	37,50	0,00	37,50
M002	85,71	-25,00	60,71
M003	14,29	75,00	89,29
M004	62,50	25,00	87,50
M005	-85,71	25,00	-60,71

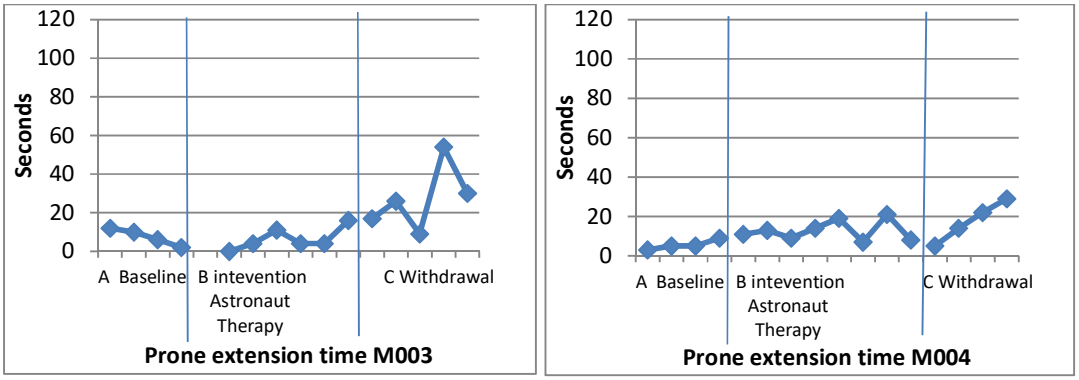
Post-Astronaut Training to Withdrawal (B-A)

Withdrawal improvements in terms of the time prone extension was held for 25% between post-Astronaut Training (B) and Withdrawal (A) was seen in participants

M004 and M005, with M003 having a 75% increase. However, M002's time decreased by 25%.

Overall, improvement of over 50% between pre-Astronaut Training (A) and Withdrawal (A) was seen in M002, M003 and M004, with M001 improving by less than 50%. M005's time held decreased by more than 50% (Table 4.8: Figure 4.6).





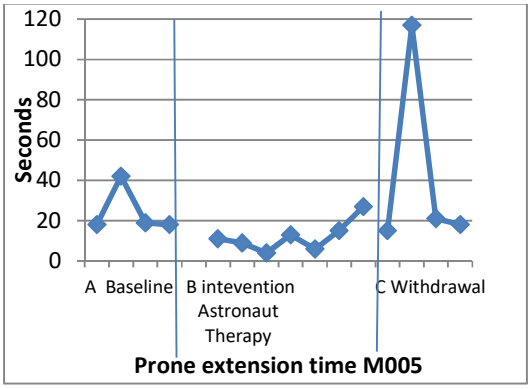


Figure 4.6 Scores for the time of prone extension at Baseline and Pre-Astronaut Training (A), Post-Astronaut Training (B) and Withdrawal (A) for each participant (n=5)

Only participant M003 had an improvement in the quality and time for which prone extension was held during the Intervention (B) and Withdrawal phases (A). M001 and M003 showed improvements between pre-Astronaut Training (A) and Withdrawal (A) in both prone extension time and quality. All participants except one (M005) had an improvement in the time they could hold the prone position during the Intervention phase (B). That participant and two others (M003 and M004) showed improvement during the Withdrawal phase (A). The greatest percentage improvement for most participants was in prone extension time occurring during the Intervention phase (B) with equal improvement in quality and time at Withdrawal phase (A).

4.5.3 Supine flexion quality

Figure 4.7 shows the line graph of supine flexion quality throughout the phases of the study for each participant with Table 4.10 showing the improvement rates between the different phases. .

Pre-Astronaut Training to Post-Astronaut Training (A-B)

The quality of supine flexion improved in all participants, except M005 who stayed the same between the pre-Astronaut Training (A) and post-Astronaut Training (B). However, the only participant (M001) had improvement greater than 50% (Table 4.10: Figure 4.7).

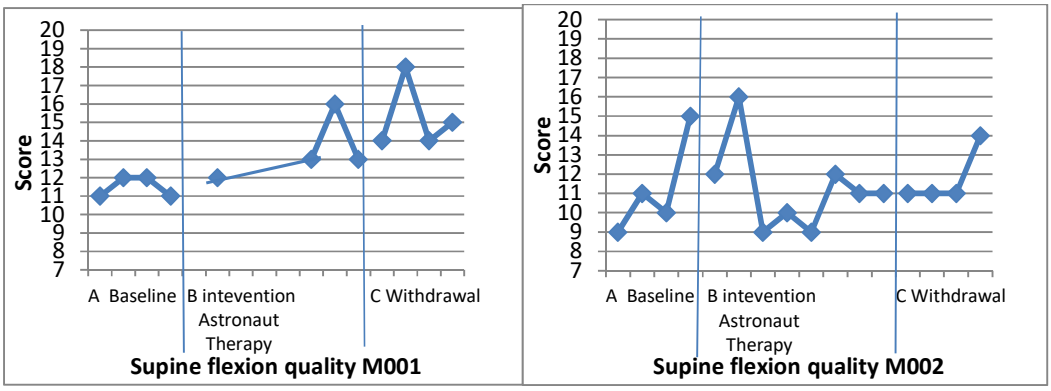
Table 4.10: Table to show the improvement rate percentage in quality of supine flexion between pre-Astronaut Training (A), post-Astronaut Training (B) and Withdrawal (A)

	Improvement rate between pre-AT and post-AT (A-B)	Improvement rate between post-AT and Withdrawal AT (B-A)	Improvement rate difference between pre-Astronaut Training and Withdrawal (A-A)
M001	75,00	25,00	100,00
M002	12,50	0,00	12,50
M003	14,29	25,00	39,29
M004	25,00	0,00	25,00
M005	0,00	0,00	0,00

Post-Astronaut Training to Withdrawal (B-A)

At Withdrawal, improvements between post-Astronaut Training (B) and Withdrawal (A) in terms of the quality of supine flexion of less than 50%, was found in participants M001 and M003. There was no further improvement for the remaining participants.

Overall, M001 showed a 100% improvement from pre-Astronaut Training (A) to Withdrawal (A), with M002, M003 and M004 showing an improvement of less than 50%. M005 was the only participant to show 0% improvement in overall quality (Table 4.9: Figure 4.7).



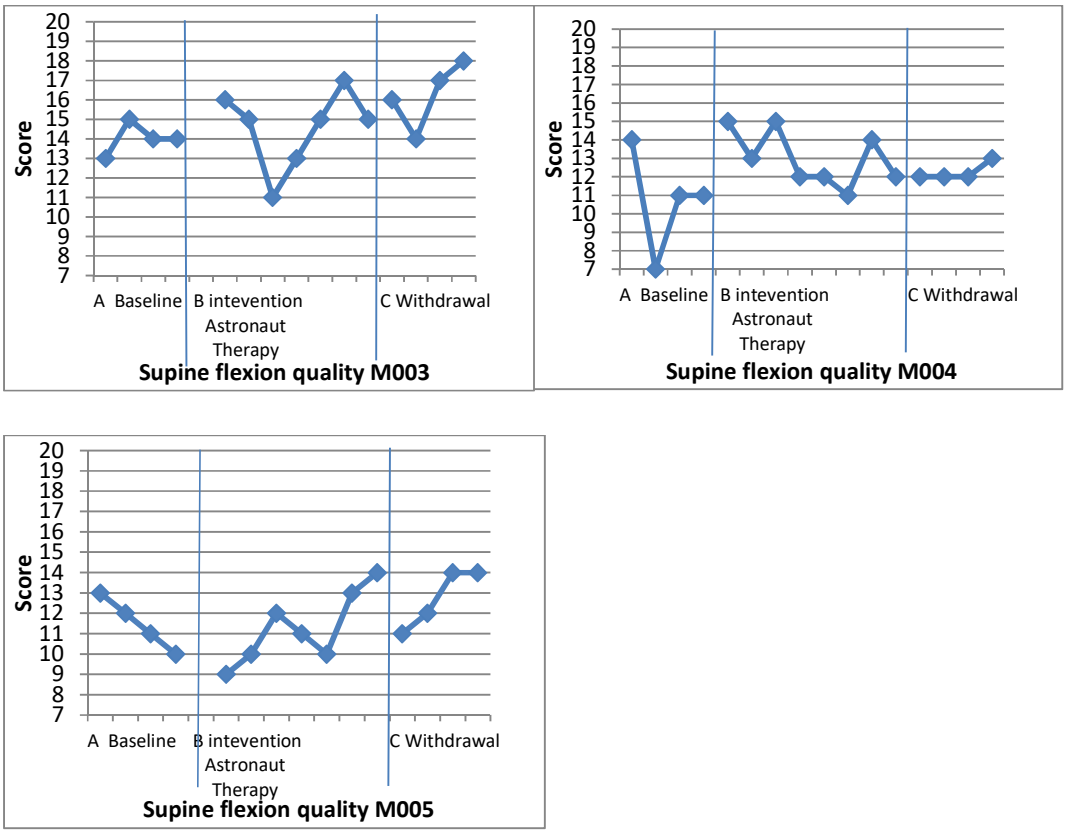


Figure 4.7 Scores for the quality of supine flexion at Baseline and Pre-Astronaut Training (A), Post-Astronaut Training (B) and Withdrawal (A) for each participant (n=5)

4.5.4 Supine flexion time

Figure 4.8 shows the line graph of supine flexion time duration throughout the phases of the study for each participant with Table 4.11 showing the improvement rate percentage between the phases.

Pre-Astronaut Training to Post-Astronaut Training (A-B)

The time supine flexion could be held improved in M002, M003 and M004 in the time between the pre-Astronaut Training (A) and post-Astronaut Training (B). However, only participants M002 and M004 showed improvement greater than 50% (Table 4.10:

Figure 4.8). M005 was the only participant to decrease in the time held post-Astronaut Training.

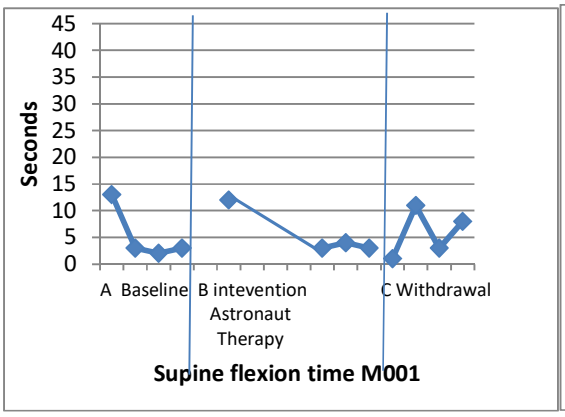
Table 4.11: Table to show the improvement rate percentage in time of supine flexion between pre-Astronaut Training (A), post-Astronaut Training (B) and Withdrawal (A)

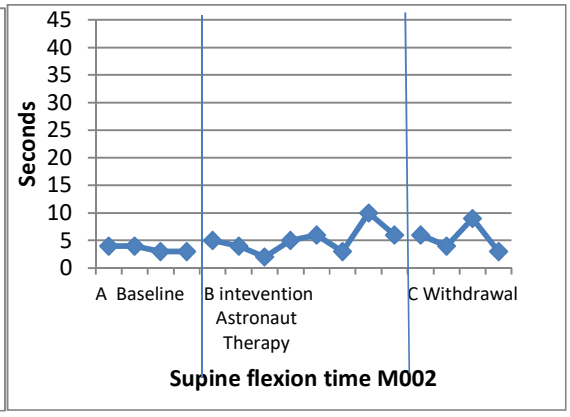
	Improvement rate between pre-AT and post-AT (A-B)	Improvement rate between post-AT and Withdrawal AT (B-A)	Improvement rate difference between pre-Astronaut Training and Withdrawal (A-A)
M001	0,00	-25,00	-25,00
M002	50,00	0,00	50,00
M003	14,29	50,00	64,29
M004	87,50	0,00	87,50
M005	-28,57	25,00	-3,57

Post-Astronaut Training to Withdrawal (B-A)

At Withdrawal, improvements in terms of the time supine flexion could be held for 50% or less between post-Astronaut Training (B) and Withdrawal (A), was noted in M003 and M005. However, M001 displayed a decrease of 25%.

Overall, between pre-Astronaut Training (A) and Withdrawal (A), three participants improved by 50% and above, namely M002, M003 and M004. M001 and M002 deteriorated by less than 30% (Table 4.10: Figure 4.8).





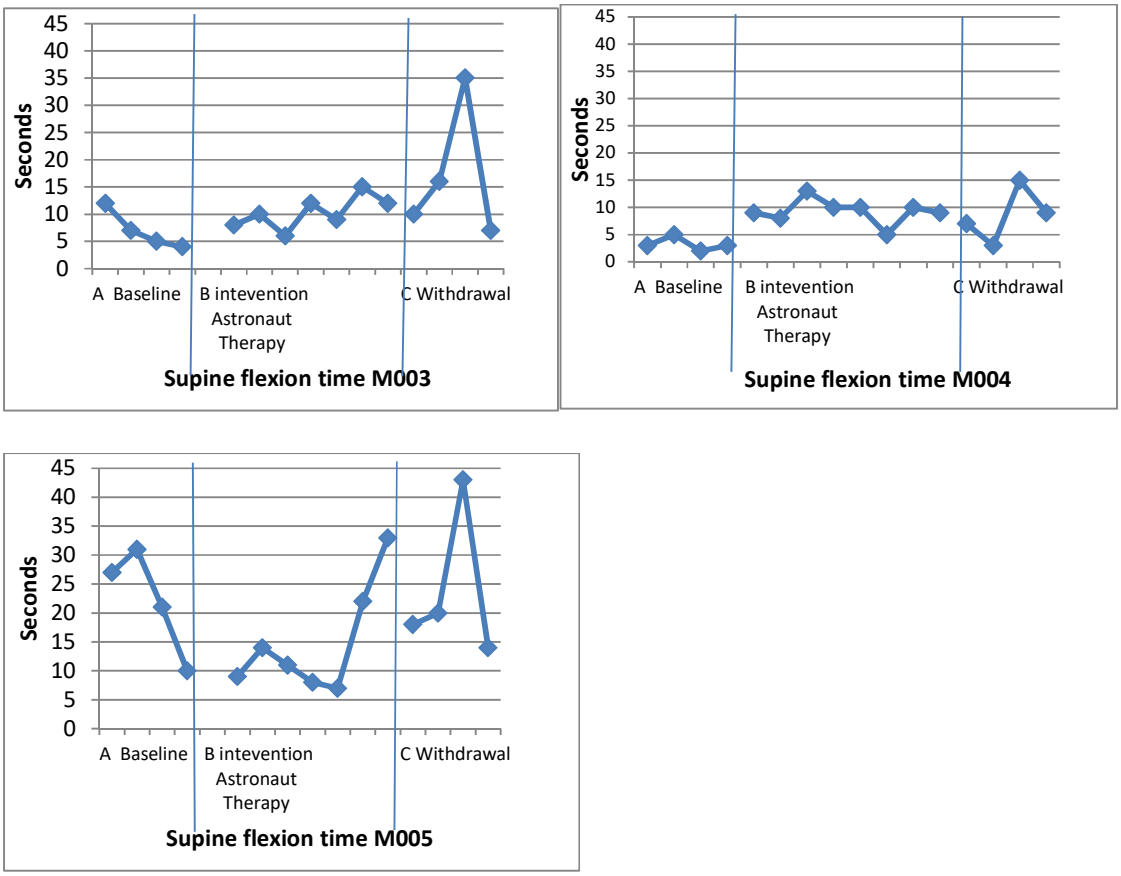


Figure 4.8 Scores for the time of supine flexion at Baseline and Pre-Astronaut Training (A), Post-Astronaut Training (B) and Withdrawal (A) for each participant (n=5)

Only participant M003 showed improvement in the quality and time for which supine flexion was held during the Intervention (B) and Withdrawal phases (A). For the other participants, all displayed improvement in the quality of their supine flexion during the Intervention phase (B) except M005, while another, M001, continued to improve during the Withdrawal phase (A). Three participants showed improvement in the time they could hold the supine flexion during the Intervention phase (B). In the Withdrawal phase (A), two participants displayed an improvement of 25% and above. The greatest percentage improvement for most participants in both quality and time of supine flexion occurred during the Intervention phase (B).

4.6 Summary

Of the improvement seen for the pre and post assessments, the improvement in balance and PRN was greatest in the Withdrawal phase (A), with the greatest improvement in in-seat posture and in-seat movement occurring during the Intervention phase (B). For the postural control assessments, only participants M001 and M004, both of whom were over-reactive to rotatory input, continued to show improvement in the Withdrawal phase (A). The same two participants showed very little change in PRN during the post-Astronaut Training phase (B) of the study.

The null hypothesis, therefore, is rejected as there *was* a change in the vestibular processing relating to postural control and in-seat behaviour when the participants received intervention in the form of the Astronaut Training Protocol. The null hypothesis can only be rejected for positive change in in-seat posture for the post-Astronaut Training (B) scores. Although it can be rejected for the other assessments, balance, PRN and in-seat movement as change occurred, the change varied between positive and negative change for different participants.

For the repeated measures, the improvement was seen in the quality and time the positions could be held with a greater number of participants showing an improvement in the quality and time of supine flexion as well as in the time of prone extension. Most of the improvement for these positions occurred in the Intervention phase (B) with only participant M003 showing consistent improvement for prone extension and supine flexion over the Intervention phase (B) and the Withdrawal phase (A).

The null hypothesis, therefore, is rejected as there was a change in the vestibular processing relating to prone extension and supine flexion with positive or negative change for all participants in terms of time. A similar result was found for quality, except for participants M002 and M005 who showed no change in prone extension and supine flexion respectively.

CHAPTER 5: DISCUSSION

5.1 Introduction

This chapter presents a discussion of the results of the implementation of the Astronaut Training Protocol and its effect on vestibular function and postural control. Both needed to support an upright posture during table-top work necessary for effective participation in the classroom. The conversation also considers change following the Astronaut Training Protocol and carryover once the intervention was withdrawn. Since a single subject research design was followed, each participant is discussed separately as they presented with different types of sensory processing and challenges thus impacting on the implementation of the intervention. As a result, the Astronaut Training Protocol had to be adapted accordingly for each participant. This is important to note as not all participants responded to the intervention in the same way and theory from the literature is used to reflect on possible differences. Demographics, relevant background history, tolerance for rotational input and the researcher's reflections will be included.

5.2 Demographics

As previously stated, five participants took part in the research, ranging between five years three months at the start of the data collection, and six years four months at the end of the Withdrawal phase. Four participants were male, and one was female. There were more males attending the occupational therapy practice where the study took place, which correlates to the fact that learning difficulties and concentration difficulties are more prevalent in males (Ramtekkar, et al., 2010).

The age range of the participants was favourable to the study since it is children within this range who are generally completing their Grade R year. This is relevant since Grade R is considered to be the first formal school year and according to the Department of Basic Education (2011), although this year is supposed to be a year of

incidental, play-based learning and free play; children are still expected to work on their fine motor skills such as eye-hand coordination, cutting and copying words and letters, as well as perceptual skills. They are required to attend, listen to the teacher, follow simple instructions and write “using a correct sitting position” (Department of Basic Education, 2011, p. 41). Although teachers can teach these skills in a variety of different seated positions such as on the floor, lying in prone or standing, most children spend a large portion of their day seated at a desk (Amundson, 2005).

5.3 Astronaut Training Protocol

Many children with learning disabilities have difficulties in vestibular processing (Ayers, 1982) and have been noted to have difficulty keeping an upright posture, become fidgety or slouch which impacts their ability to attend in the classroom and complete fine motor work. Literature states that the vestibular system is responsible for maintaining an upright posture (Lane, 2002). The Astronaut Training Protocol was designed to improve the vestibular system along with the visual and auditory systems. There is little published research on the effectiveness of this programme. Since the link between postural control and vestibular function is strong and all the assessments used evaluated components of each, all the results for the objectives for each participant are discussed together.

5.3.1 Vestibular function and postural control

5.3.1.1 Participant M001

M001 was over-reactive to rotational vestibular input and thus only two to four revolutions were done in each Astronaut Training session. Signs of over-reactivity include poor concentration, defensive behaviour, unstable mood, excessive dizziness, nausea, vomiting, change in pallor, hypotension and poor balance (Su, et al., 2015).

M001 displayed autonomic nervous system responses indicative of over-reactivity such as flushing of the cheeks, yawning and headaches (Kawar, et al., 2005). Strategies were put into place when these signs were observed to overcome the over-reactivity, such as proprioceptive activities like carrying and pushing heavy objects (Su, et al., 2015), placing hands on the head and jumping, pushing of the body into crash mats, and applying ice cubes to the hand, the base of the skull and temples (Kawar, et al., 2005). The eight Astronaut Training sessions were done more frequently over a shorter period, approximately three times per week over three weeks, whereas with the other participants (M002, M003 and M005), the programme, on average was completed once to twice per week over five weeks. This intensity of the programme may have impacted the results.

M001 showed greater improvements in balance, PRN, in-seat posture and in-seat movement at Withdrawal (A), with in-seat posture having a greater improvement post-Astronaut Training (B). PRN and in-seat movement remained the same post-Astronaut Training (B), with balance deteriorating. A possibility of M001's balance scores worsening in this phase could be due to the Astronaut Training being disorganising for him and may have negatively impacted his balance. M001's motivation may have impacted his willingness to maintain this position during the assessment as he also displayed reduced motivation during the repeated measure tests. M001's PRN scores may have improved at Withdrawal (A) due to improved integration of the vestibular system. Vestibular input can accumulate and last in the body for a few hours after receiving stimulation (Lane, 2002). Continuous vestibular input at the right duration and intensity may result in better integration of the vestibular system and may explain the changes observed in the scores for M001 and M004.

M001's improved in-seat posture post-Astronaut Training (B) correlates to improvement in prone extension quality and time and supine flexion quality. He may have shown greater improvements during this phase, as stimulating the vestibular system through the Astronaut Training provides innervation to the neck and upper trunk extensors thus facilitating an upright posture (Bundy, 2002). He maintained these scores into Withdrawal (A), however supine flexion time deteriorated by 25%. This

maintenance of the static posture of supine flexion is likely due to the innervation of the otolith organs in the vestibular system (Bundy & Fisher, 1981). Without receiving vestibular input via the Astronaut Training Protocol, he had difficulty assuming this posture with the improved quality and using sufficient postural control to hold it for a longer time. His in-seat posture and in-seat movement scores continued to improve into Withdrawal.

5.3.1.2 Participant M002

M002 displayed concentration difficulties and impulsivity during the research which were some of the reasons for initial referral to occupational therapy. Following the research, M002 was diagnosed with ADHD and placed on Ritalin. Studies have shown children with ADHD have subtle abnormalities in the central nervous system (Castellanos, et al., 2002), sensory processing difficulties (Panagiotid, et al., 2018) and almost half of children with ADHD have vestibular deficits which impact the semi-circular canals and otolith organs (Clark, et al., 2008). One study showed that vestibular stimulation as a therapeutic programme had a positive effect on children with ADHD (Arnold, et al., 1985). M002 was able to tolerate more rotational input than average (Su, et al., 2015), however, the number of rotations was less than the research by Arnold et al (1985). He could tolerate up to 60 revolutions during the Astronaut Training Protocol, thus receiving a large amount of vestibular input. M002 displayed improvements in vestibular function of PRN and balance both post-Astronaut Training (B) and at Withdrawal (A).

M002's in-seat posture and in-seat movement had greater improvements post-Astronaut Training (B) which were congruent to improvements in prone extension time, supine flexion quality and time post-Astronaut Training. Thus, showing with vestibular input an improvement in postural control and endurance was seen. Without Astronaut Training, he had a slight deterioration at Withdrawal (A) in prone extension time which appeared to impact negatively on his in-seat posture and in-seat movement due to reduced maintenance of the static posture (Bundy & Fisher, 1981). M002 therefore

benefitted from the vestibular stimulation during the Astronaut Training Protocol and would benefit from further sessions.

5.3.1.3 Participant M003

M003 improved in processing vestibular input and better postural control was seen in balance, in-seat posture and in-seat movement post-Astronaut Training (B). She could tolerate rotary input of 28 to 54 rotations during the Astronaut Training sessions which appeared to have a positive impact on the results. However, these scores deteriorated at Withdrawal due to the inconsistency of therapy in the form of a 13-week break between the last Astronaut Training session and the Withdrawal reassessments. The inconsistency of therapy could not be avoided due to school holidays and conflicting schedules which appeared to impact the results. Like M002, M003 was diagnosed with ADHD, however, this diagnosis occurred *during* the Withdrawal phase and she started taking Concerta the day before Withdrawal session three. Concerta acts on the lower brain stem as a stimulant and can release the inhibition of this area which can affect nystagmus (Kimball, 1986). This could, therefore, have impacted on her PRN score at Withdrawal.

M003's repeated measures of prone extension and supine flexion improved both post-Astronaut Training (B) and at Withdrawal (A). Post-Astronaut Training, her prone extension time, supine flexion time and quality all improved by 14%, with prone extension quality being at 43%. These had a positive impact on balance, in-seat posture and in-seat movement scores. At Withdrawal session three (when she started taking Concerta), there was a spike in her scores of prone extension and supine flexion quality and time. This could indicate that starting Concerta may have had an impact on her motor performance. According to Bart, et al. (2010), 33% of children with ADHD and Developmental Coordination Disorder (DCD) displayed better motor performance when taking methylphenidate. Withdrawal session four took place two months later when she was more settled on the medication with her scores being more similar to previous scores in the Withdrawal phase. Unlike Brossard-Racine, et al.'s (2012)

study, M003's motor skills did not continue to improve at Withdrawal assessments while on Concerta.

It is unclear why the improvement of supine flexion and prone extension in Withdrawal (A) did not translate to improvements in balance, in-seat posture and in-seat movement as with the other participants. It could possibly be due to the inconsistency of therapy. M003's results can be equated to M002's in that their scores deteriorated when the Astronaut Training Protocol was stopped and therefore it can be deduced that she may have benefitted from continued therapy using the Protocol.

5.3.1.4 Participant M004

Like M001, M004 displayed autonomic nervous system signs of over-reactivity to rotary input and needed strategies to help with his over-stimulation. He displayed flushed cheeks and asked for deep pressure or proprioceptive input such as carrying and pushing heavy objects to help with his regulation. He was able to tolerate 18 to 41 rotations over the course of the programme. He was also seen frequently for Astronaut Training which was three times per week over a three week period.

M004 showed similar improvements during Withdrawal as M001 in terms of PRN, in-seat movement and in-seat posture. His PRN scores remained relatively consistent throughout post-Astronaut Training (B) and Withdrawal (A). His balance improved slightly but still remained in the below average range post-Astronaut Training (B) and Withdrawal (A). This may be due to his balance difficulties being postural- based rather than only vestibular, such as that of poor postural alignment, stability of the feet and ankles and hip co-contraction (Magrun, 2016). In-seat posture and in-seat movement improved post-Astronaut Training and continued to improve into Withdrawal (A).

He displayed a decrease in quality of 50% in prone extension post-Astronaut Training, yet his time in maintaining the position increased by 63%. This could possibly indicate that he was compensating by fixating proximal and distant joints in order to have improved endurance and time scores. At Withdrawal he maintained his quality, but

time increased by 25%, showing further improvement in maintaining this position. Supine flexion quality and time improved post-Astronaut Training (B) and remained the same at Withdrawal (A). This improvement translated into improved in-seat movement at both post-Astronaut Training (B) and at Withdrawal (A) - he was thus able to sit with better posture and less in-seat movement. Therefore, improvements in vestibular function were mostly seen post-Astronaut Training in supine flexion and prone extension which had a positive impact on his postural control for in-seat behaviour.

5.3.1.5 Participant M005

M005 displayed a different profile to the other participants in that his PRN scores were unfavourably high. Prolonged nystagmus is not always due to poor vestibular processing, but rather “deficits in higher-level integrated cortical functioning” (Ayres, 2012, p. 199; Ottenbacher, et al., 1980). However, changes in prolonged nystagmus can be seen through sensory integration intervention (Ottenbacher, 1982). M005 displayed improvements post-Astronaut Training (B) in terms of balance, slightly lowered PRN and in-seat posture. For in-seat movement, he started with very little movement which increased during post-Astronaut Training (B) and then considerably more at Withdrawal (A). M005 used more fixation during in-seat movement pre-Astronaut Training (A) by sitting with his chair pushed very close to the table, thus using the backrest of the chair for external support. He rested his head on his hand with his elbow on the table, again doing this for extra external support. Post-Astronaut Training (B), he did not show as many signs of fixation in that he only rested his head on his hand briefly, sat upright without his back against the chair, and started using more trunk activation, thus appearing more fidgety. His improved posture was reflected in his improved in-seat posture scores post-Astronaut Training (B). M005’s weekly attendance to therapy sessions was not consistent throughout research with greater inconsistencies during the Withdrawal phase.

At Withdrawal (A), M005's balance remained the same, however, there was a deterioration in the PRN score, as were the scores for in-seat posture and in-seat movement. His therapy attendance, like M003, was inconsistent at this phase with the Withdrawal reassessment taking place 11 weeks post-Astronaut Training, instead of at the optimal four-week mark. His PRN scores deteriorated more than Baseline which could be because he did not receive sufficient vestibular input due to the inconsistency of the therapy sessions. According to Ottenbacher (1982), sensory integration occupational therapy three times per week for 50 minutes over 20 weeks had a change in three learning disabled children's PRN scores. One child had a prolonged PRN score and through intervention, habituated to the input while his scores decreased into the typical range. With further Astronaut Training therapy and consistency of therapy, M005 may have had a larger improvement in PRN. This further emphasises the need for regular occupational therapy in order to have a significant impact on PRN.

M005's in-seat posture scores deteriorated at Withdrawal (A) but were better than the Baseline (A). During the in-seat movement assessment at Withdrawal (A), he was excitable and chatty, he fidgeted with the accelerometer, and also dropped several pegs on the floor. His chair was further away from the table and thus he used more trunk movements when reaching for pegs and looking for the dropped objects on the floor. He did not fixate by resting his back against the backrest of the chair or on his hand. The vestibular descending tracts influence the gamma fibres to produce muscular co-contraction in the higher levels of the trunk and upper limbs (de Quiros & Schrager, 1978). Through the stimulation of the utricle and semi-circular canals given via the Astronaut Training, an improvement in activation of trunk extensor muscles to opposed gravity and improvement tonic co-contraction of the trunk and neck was seen (Lane, 2002). M005 did not need external support to keep an upright posture but rather used his trunk co-contraction when reaching for objects, thus appearing more fidgety.

A deterioration was seen post-Astronaut Training (B) for prone extension quality and time, with supine flexion quality remaining the same, but time deteriorating by 28.57%. M005 displayed poor motivation during these repeated measure tests and it is suspected that this influenced his ability, resulting in his scattered scores. Therefore,

this was not necessarily a true reflection of his ability. When these tests were done informally during therapy, he displayed improved endurance and quality. Greater improvement was seen at Withdrawal (A) pertaining to M005's quality and time of prone extension with time of supine flexion improving as well, indicating improved postural control. He may have become more fidgety during in-seat movement at Withdrawal (A) as his core muscles were stronger and he no longer needed to fixate to keep himself upright, resulting in increased in-seat movement. The greater in-seat movement at Withdrawal (A) can be considered positive for this participant as he was no longer fixating but rather activating his co-contraction of his trunk.

5.4 Effects of the Astronaut Training Protocol on vestibular function and postural control

Evidence showed that after the participants received Astronaut Training Intervention (B) and at Withdrawal of Intervention (A), there was a general improvement in effect sizes, indicating a moderate clinical improvement in balance and a large clinical improvement in PRN, in-seat posture and in-seat movement. These improvements occurred in different phases of the research which will be discussed.

Balance scores improved post-Astronaut Training (B) but had greater improvements at Withdrawal (A) as indicated by the slightly larger effect size. All participants except M001 showed improvements post-Astronaut Training and his score may have had an impact on the overall effect size. At Withdrawal (A), all participants showed improvement or maintained the same score except for M003 whose balance worsened. The improvement in balance reinforces the literature stating that stimulation of the otolith organs has an impact on balance (Lane, 2002). An overall improvement in balance was seen during the Astronaut Training Protocol and further improvement was seen through stimulating the otolith organs in sensory based occupational therapy by working on the vestibular system using a variety of swings, balancing activities and inverting the body during games. Other factors that could affect balance are righting and equilibrium reactions (Bundy, 2002), biomechanical difficulties in body alignment,

ankle stability and anticipatory postural adjustments (Horak, et al., 2009) and proprioception (Magrun, 2016). Some of these areas were observed and addressed but not specifically targeted during the Astronaut Training. These areas are, however, often addressed in sensory integration based occupational therapy, which could explain why further improvement was seen at Withdrawal.

There was an improvement in PRN at Withdrawal with a large effect size indicating that there may be a latent effect on the vestibular system. No research was found to support this finding of a latent effect on the vestibular system and therefore more research in this regard is recommended. All participants showed positive changes in PRN except for M005. In participants M002 and M003, the improvement in PRN during Withdrawal (A) was paired with an increase in their in-seat posture and in-seat movement scores when the Astronaut Training was withdrawn, indicating reduced posture and increased fidgety behaviour and thus the need for continued input. The need for continued vestibular input in these two participants who also presented with concentration problems, and who were later placed on medication, is supported by other studies. Clark, et al. (2008) explained that vestibular stimulation of the semi-circular canals and otolith system in children with ADHD is effective in reducing the effects of ADHD when done three times per week for 12 weeks. While these studies also showed some maintenance of gains in reduced impulsivity on follow up, they did not measure vestibular function or postural control and suggested continued treatment may be beneficial (Arnold, et al., 1985).

The Astronaut Training Protocol can be considered to have a positive impact on a child's in-seat posture and in-seat movement as seen by the large clinical effect on these two areas post-Astronaut Training (B). Co-contraction of the trunk shares a high correlation with PRN as bilateral facilitation of neck and upper-trunk muscles are partially based on semi-circular canal inputs transported via the lateral vestibular spinal tract which receives information from both the otolith organs and semi-circular canals. These then innervate the muscles in the spinal cord of the cervical, lumbar and sacral areas (Shumway-Cook & Woollacott, 2012; Lane, 2002) which then facilitate postural control of upright posture against gravity. M001 and M004, who were over-reactive

and had problems processing vestibular input, continued to show improvements in both PRN and in-seat movement at Withdrawal (A).

The total improvement rate in prone extension indicated that three participants (M001, M003, M005) improved in quality and four improved in time (M001, M002, M003, M004). On average, improvements in prone extension time occurred during the post-Astronaut Training (B) (except M005) and Withdrawal (A) (except M002), whereas improvement in quality occurred during Withdrawal phase (A) where M003 and M005 showed improvements and other participants maintained their scores. Assuming the position of prone extension is a dynamic process which requires the activation of the semi-circular canals. Maintaining the prone extension over time is a static position which is likely due to the innervation of the otolith organs. Stimulating the vestibular system provides innervation to the neck and upper trunk extensors (Bundy, 2002). This is supported by research which found high-threshold, otolith detected movement is needed for maintaining both prone extension and a static sitting position (Bundy & Fisher, 1981). Therefore, the stimulation of both the semi-circular canals and otolith organs during the Astronaut Training Intervention (B) had a greater effect on the total time of maintaining the prone extension position than the quality.

Supine flexion showed greater improvements in quality post-Astronaut Training (B). This could indicate that due to the activation of the semi-circular canals and otolith organs, there was improved quality of chin flexion and righting reactions when assuming the supine flexion position. This indicates improvement along the medial vestibular spinal pathway which innervates the flexors of the muscles of the cervical spinal cord (Lane, 2002). There was no deterioration at Withdrawal (A), with M001 and M003 showing further improvement. Supine flexion time showed similar improvement to prone extension time with three participants (M002, M003, M004) improving the time it took to maintain the position post-Astronaut Training (B). This too was greater post-Astronaut Training (B) than at Withdrawal (A).

Overall three out of five participants had shown improvement in prone extension quality and four had improvements in the time required to maintain the position. In supine flexion, the quality of the position of four participants had shown improvements and

three had an improvement in time. With the exception of participant M005, most of the improvement in both quality and time in prone extension and supine flexion occurred during the Astronaut Training Intervention (B).

Improvements of postural control into withdrawal may not have been seen as the programme may have needed to be continued over a longer period of time. Or another eight sessions may have been needed after the withdrawal phase. Improvements in postural control rely on facilitating anti-gravity movements, postural reactions, sensory organisation and anticipatory postural control (Nichols, 2005). The structured activities in the Astronaut Training allowed for most of these areas to be addressed. However, during sensory integration based occupational therapy, a child-directed approach is generally used with the therapist assisting in scaffolding the activity to the just-right challenge (Schaaf & Mailloux, 2015). The child may not be motivated to work on these anti-gravity positions and may give up due to reduced postural control or endurance. The Astronaut Training Protocol can, therefore, be seen as a useful adjunctive therapeutic tool in sensory integration based occupational therapy sessions.

Sensory integration based occupational therapy places more emphasis on the sensory systems particularly the vestibular system. Therefore, it appears that more changes were seen in the vestibular system at withdrawal after the sensory based occupational therapy sessions. Perhaps more structured postural control based activities (as stated in the Astronaut Training Protocol booklet) should be done in occupational therapy post Astronaut Training to allow for more carryover of postural control.

There was an improvement in vestibular function and postural control after participants received Astronaut Training intervention, thus having a positive impact on their posture and ability to stay seated. It can be assumed that this will have a carryover into the classroom and thus assist in a child's in-seat behaviour as well as in classroom participation. According to dual-task performance theory, with improvements in these areas, the child will most likely not be focused on their posture but rather on what is being taught in the classroom (Shumway-Cook & Woollacott, 2010). It is recommended that additional Astronaut Training sessions be done to allow for more carryover of postural control into the Withdrawal phase. Further research can be done

into qualitative observations from teachers as to the effectiveness and carryover of the programme.

5.4.1 Factors affecting the efficacy of the intervention

5.4.1.1 Over-reactivity to rotation versus non-reactive participants

Two participants (M001 and M004) displayed signs of over-reactivity to rotational input. They displayed autonomic signs such as headaches, flushing, yawning and dizziness. This indicates an increased sensitivity of the receptors of the vestibular system, as the central nervous system found it increasingly difficult to modulate the input in the reticular formation (Lane, 2002). Their ability to determine the planes of movement were typical, as their PRN scores were within the average range. The Astronaut Training Protocol was, therefore, adapted by doing fewer rotations in line with their tolerance for this input and was built up over the eight sessions (still according to each individual's tolerance). With M005, he did not display vestibular over-reactivity but rather insufficient central nervous system inhibition of the oculomotor reflex that could be seen in the prolonged PRN scores (Ayres, 2012). He could, therefore, tolerate more spinning without showing autonomic signs of over-reactivity. It is important to distinguish between the two as this can impact on the safe implementation of the Astronaut Training Protocol. Participants who were not over-reactive to rotational input did not display autonomic nervous system signs and generally enjoyed the spinning.

According to Su, et al. (2015), there is a large variation amongst children of different ages in terms of how much passive vestibular rotation can be tolerated. They found that children who were in a similar age range as in this research could tolerate a mean of 36 passive rotations. They suggested starting under the mean for children with over-reactivity to rotary input and above the mean with no more than 1.96 standard deviations for children with hypo-responsivity. This study only looked at the stimulation of the horizontal semi-circular canal and not the other vestibular receptors which are

stimulated in the Astronaut Training Protocol. It is therefore important for the treating therapist to use clinical judgement when implementing the programme.

5.4.1.2 Sensitivity of the assessments

The PRN test was administered by an occupational therapist with training in this assessment. This test has good interrater reliability of 0.98 (Ayres, 2012; Ayres, 1976) and test-retest reliability of 0.80 (Kimball, 1981). However, the PRN test does not completely eliminate visual input. Research has shown that visual fixation following PRN can inhibit the nystagmus (Ottenbacher, 1982) thus affecting the scores and suggests it is more accurate to do this test with vision occluded (Arnold, et al., 1985).

The in-seat posture assessment was adapted from the Chailey Levels of Postural Ability (Pountney, et al., 2004) for the purpose of this study and norms were measured against the same criteria for each participant. However, this was not a standardised test and therefore there were no z scores for the in-seat posture assessment.

There is no literature that indicates what the normal amount of in-seat movement during table-top activities is for children. As a result, in-seat movement raw scores were compared against their own movement scores to determine change.

It is suspected that motivation to perform during assessments impacted scoring. This was not formally assessed but informal observations were made at each session. Some participants were motivated to try their best at Baseline and then lost interest over the course of research. Many wanted to complete the task quickly as they did not enjoy it. According to Sideridis (2003), children with learning difficulties display feelings of helplessness, lethargy and poor motivation if they perceive success is beyond their ability, compared to typically developing children. Some participants found the repeated measures of prone extension and supine flexion difficult and thus did not appear to maintain these positions to their best ability. M001 refused to do four of the supine flexion tests describing it as “boring”. Difficulties in motivation were evident in the variation in time scores over the study period for all repeated assessments. The

repeated measures were not done at consistent time frames due to school holidays and parent schedules. This was evident in M003 and M005 where large peaks were seen at the Withdrawal phase - the phase of inconsistent therapy. It was found that the tests for prone extension and supine flexion may not have been sensitive enough to assess small differences. This could be due to the internal consistency reliability not being strong enough: 0.6-0.8 in prone extension and 0.6-0.7 for supine flexion (Fanchiang, 1989).

5.4.1.3 Period for and intensity of Astronaut Training

A weakness of the study was the differing time periods that were seen during the implementation of the Astronaut Training Protocol and the period before the Withdrawal scores were assessed. Data was collected over 12 sessions, however, as stated previously, there was a long break in the Withdrawal phase for two participants (M003 and M005) due to school holidays and parent schedules. It therefore took 23 weeks to collect the data as opposed to 12 weeks. This break from occupational therapy before the Withdrawal scores was assessed may have negatively impacted on the findings as they both displayed a similar trend.

The preferred intensity of the Astronaut Training in this research (eight sessions over three weeks) was not viable due to parents' schedules. Two of the participants (M001 and M004) received the eight Astronaut Training sessions with this intensity. These participants happened to be over-reactive to vestibular input which may have impacted the results. The average time Astronaut Training took place was five weeks. It is recommended that the Astronaut Training Protocol be done more intensively if a child is over-reactive to vestibular input (Kawar, et al., 2005). Although the effect of intensity of Astronaut Training has not been researched, other studies which have looked at vestibular stimulation through rotation were done three times per week for 12 weeks (Bhatara, et al., 1981; Clark, et al., 2008). This indicates that it may be beneficial for the Astronaut Training Protocol to be done over this time period as well.

5.4.1.4 Consistency of therapy

From the results, it can be seen that consistency of therapy appeared to impact the results in the Withdrawal phase (A) as seen in M003 and M005. Therapy was inconsistent in these participants due to school holidays, participants getting sick and parent schedules. Every effort was made to arrange alternative therapy dates however this was not viable. Non-compliance to therapy can negatively impact on the progress of a child (Cameron, 1996).

5.5 Strengths and limitations of the study

5.5.1 Limitations

There was some limitation in the study regarding the sensitivity and implementation of assessments as discussed above. At times, the scoring of the videoed assessments was challenging due to the participants' clothing. For future research, it would be beneficial to request that participating children wear tight-fighting clothes as this would likely assist in more accurate scoring. It would have also been beneficial to include a standardised assessment to assess each participant's sensory profile at the beginning of research to analyse their sensory systems which may assist in determining how they respond to the programme. There was a large variability of results in each participant, therefore, making it difficult to generalise findings. It is recommended that more research be done into how children who are over-reactive to vestibular input respond to the Astronaut Training Protocol versus children who are not over-reactive to this input.

5.5.2 Strengths

The assessments in this study were carefully analysed with literature and chosen according to the vestibular and postural control assessments that are often used in

clinical practice. Assessments that were chosen were quick to administer so as not to take up too much of the participants' regular occupational therapy time. Assessments were adapted to fit in with the requirements of the study using the available literature, clinical experience and in close consultation with other experienced occupational therapists. Repeated measures were used in the event of a participant having an "off day". The treating occupational therapist remained consistent throughout the research which allowed for a good understanding of each participant and enabled the ability to adapt the Astronaut Training Protocol appropriately. She had attended the Astronaut Training course and had experience using the Protocol. Implementation of the Astronaut Training Protocol was discussed with Mary Kawar to ensure it was done suitably to target the vestibular system and postural control.

CHAPTER 6 CONCLUSION

6.1 Conclusions

Children spend a large portion of their school day seated at a desk (Amundson, 2005). Difficulties being able to maintain an appropriate posture can impact on focus, handwriting and academic performance. Many occupational therapists treat children for difficulties in in-seat posture and in-seat movement. This research investigated the effectiveness of the Astronaut Training Protocol in treating the vestibular system that influences postural control and whether vestibular input would impact in-seat posture and in-seat movement. Findings indicate a change in vestibular function and postural control following the Astronaut Training Protocol for five participants using a single subject ABA research design. Each participant presented with different findings due to their unique difficulties.

Overall intervention with Astronaut Training (B) was determined to have an effect on changes in postural control with some improvements in vestibular functioning in terms of balance for four participants and PRN for three participants. Improvements in postural control and vestibular function were also seen in prone extension and supine flexion quality and time for most participants. A large effect size indicating a clinical change for in-seat posture and in-seat movement was found with participants seated with better posture and less fidgety behaviour following intervention with the Astronaut Training Protocol (B).

More improvement in vestibular function occurred at the Withdrawal phase (A) with regards to balance and PRN with a medium effect size on balance and large effect size for PRN, suggesting there was a carryover of vestibular input to Withdrawal from the Astronaut Training Protocol. However, participants' posture and in-seat movement did not continue to improve and deteriorated slightly. This was still an improvement from Baseline in all participants suggesting that there was still carryover four sessions post- Astronaut Training Intervention. This may indicate that participants would benefit from further Astronaut Training sessions.

Intervention using the Astronaut Training Protocol has been shown to improve vestibular function and postural control in children with in-seat posture and in-seat movement difficulties, however, the frequency and intensity of the programme still need to be confirmed.

6.2 Clinical implications

Overall, significant improvement was found for in-seat posture after intervention using the Astronaut Training Protocol (B) and a large effect size for in-seat movement using an accelerometer. This improvement was not maintained when the Astronaut Training Protocol was withdrawn (A). PRN scores continued to improve during the Withdrawal phase (A) suggesting long-lasting effects on the vestibular system. There was no clear pattern of change in the quality and time maintaining the prone extension and supine flexion. An exception is that the improvement was generally greater post-Astronaut Training (B) with some deterioration in Withdrawal (A).

It is important to look at each child holistically and individualise the protocol to suit each child's needs. Differences were evident for children with over-reactivity for rotation and those diagnosed with ADHD. While participants who showed over-reactivity to rotation benefitted in terms of improvement in in-seat posture and in-seat movement after intervention with Astronaut Training Protocol (B), they maintained this improvement in the Withdrawal phase (A). The participants with ADHD, while also improving for these aspects after intervention with Astronaut Training Protocol (B), did not maintain this improvement in the Withdrawal phase (A). The findings indicate clinical effectiveness of the Astronaut Training Protocol on in-seat posture and in-seat movement with the need for extended intervention using this Protocol to be considered for children with ADHD.

This emphasises the need to understand the vestibular system physiology and the effect of different presentations in children with learning difficulties. Therapists should

be guided by a full assessment and it is suggested that the sensory profile and sensory integration observations of each child be available to guide intervention decisions. This study provided no clear results in relation to the intensity of treatment or the duration in terms of weeks for intervention with the Astronaut Training Protocol (B) due to inconsistent application. It appears that Astronaut Training Protocol may be more effective if done three times per week. It may be beneficial for children with ADHD to do more Astronaut Training session of perhaps 12 sessions, or to be given a break from the protocol and then have another eight session block of the intervention.

6.3 Recommendations

No research has been done on the Astronaut Training Protocol as to the time frame it should be done and whether more intensive Astronaut Training sessions (three to five times per week) would be more beneficial than once to twice per week. The results of this study seem to indicate that the increased intensity of Astronaut Training Intervention may have had more of a positive impact on in-seat movement during Withdrawal (A). Therefore, research on specific groups of children with identified diagnoses of sensory difficulties, and concentration difficulties, should be considered. It is recommended that the intensity of the Astronaut Training Protocol be explored. Each participant displayed different difficulties and it is not known if the intensity of Astronaut Training Protocol would only be relevant for children with over-reactivity to vestibular input, or if similar results would be seen in children who can tolerate high-intensity rotational input. Further research into the Astronaut Training Protocol with a larger sample size is needed in an attempt to generalise these findings to the public. More research into a possible latent effect of vestibular processing on children with vestibular over-reactivity would add valuable knowledge to this field.

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Appendix A

Department of Occupational Therapy

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PERMISSION LETTER

SandtonOT
Private practice

Dear Nicole Katzenellenbogen,

Study title: Vestibular function and postural control in children receiving intervention with the Astronaut Training Protocol

Introduction:
My name is Gabrielle Katzenellenbogen and I am a sensory integration trained occupational therapist. I am currently doing research for an MSc degree in occupational therapy at the University of the Witwatersrand. I am doing research on an intervention programme - the Astronaut Training Protocol. This programme facilitates the integration of the vestibular, visual and auditory systems. Little research has been done on this programme although it appears to be effective in changing function in children with sensory integration dysfunction. I am completing a study that will investigate the impact of the Astronaut Training Programme on a child's posture and their in-seat behaviour at the desk.

Permission:
I am asking permission to complete the study at SandtonOT private practice.

What is involved in the study:
The study will require 5 children between the ages of 5 years 0 months and 8 years 11 months and take place over 16 sessions. I am inviting you to identify children who display difficulties in in-seat posture and in-seat movement may benefit from this programme. The children will be assessed at the start of the study and a 1-minute assessment of prone extension and supine flexion will be completed on them during each of their regular occupational therapy sessions over four sessions. For the next four sessions, I will add sessions of Astronaut Training for each

child who will again be assessed for 1 minute after every session of prone extension and supine flexion. The child will then be assessed for 1 minute of prone extension and supine flexion after their routine occupational therapy for another four sessions.

I will be available to present the Astronaut Training programme at a time convenient to the practice and the child. The child will need to receive the Astronaut Training 8 times. Each session will be approximately 20 minutes. I would need access to the occupational therapy gross motor room as I will need to use some equipment such as the Astronaut Training Board, hammock swing and scooter board.

I am requesting that the practice occupational therapists assist with some of the assessments as this will allow for an unbiased assessment namely balance and PRN tests. The treating therapists will need to video the child for a 1-minute assessment (prone extension and supine flexion) at the end of each therapy session. This will allow me to get a baseline of how the child is functioning.

The Astronaut Training involves doing a variety of activities to music such as spinning on a rotation (PRN) board, eye movement exercises as well as linear exercises such as swinging in the hammock swing or using a scooter board. I will measure the effectiveness of the programme by assessing the child's posture during a table-top activity in their occupational therapy session using a video, as well as in-seat movement using an accelerometer. This is a small device that is worn around the child's waist and measures the amount of energy used during movement. The child will be required to wear this during posture assessment at the table. This will be done on sessions 1, session 4, session 9 and session 16. The child will be videoed by their treating occupational therapist for 10 minutes during a table-top activity to analyse their sitting posture. Other assessments that will be done on those weeks will be a Balance test, and the PRN (spinning test). I will require one of the practice occupational therapists who has completed their sensory integration training to administer these assessments.

Risks:
Some risks involved in the study are the child may be sensitive to vestibular input and may feel nauseous after the programme. Each child will be carefully monitored for signs of overstimulation to prevent this from happening. The programme will be adapted for each child depending on their difficulties and sensory profile.

Meeting
An information meeting for parents will either be held at the practice prior to the study taking place or take place via telephone depending on what is more convenient for the parent. This will explain the study and possible side effects involved.

Benefits of being in the study
This study may benefit the child as they will receive therapy specifically focusing on their vestibular processing. This intervention may assist the children in other areas of difficulty such as posture and visual tracking. If this study is beneficial it could be used within the therapy sessions.

Feedback:
Therapists and parents will be given feedback regarding important information during the study via email and the results will be made available after the study.

Participation:
Participation is voluntary and if a parent or child refused to participate in the study or decides to discontinue during the study, there will be no penalty.

Confidentiality:
Efforts will be made to keep personal information confidential. Each child will receive a code which will be kept separate from their names to ensure confidentiality. Videos will be stored on a password-protected computer and only deleted after six years according to HPCSA regulations.

Contact details:
For more information, you can contact Gabbi at gabbikatz@gmail.com or 0826777898

Contact details of REC administrator and chair – for reporting of complaints /
If you have any questions, you can contact me on 082 677 7898. Ethical clearance has been obtained (M 170522). For any ethical concerns please contact the chairperson of the Human Research Ethics Committee at the University of Witwatersrand, Prof P Cleaton-Jones at peter.cleaton-jones@wits.ac.za. Contact details for the administrative offices: Ms. Z Ndlovu/ Mr Rhulani Mkansi/ Mr Lebo Moeng, Tel: 011 717 2700/2656/1234/1252, or email: Zanele.ndlovu@wits.ac.za; Rhulani.mkansi@wits.ac.za; Lebo.moeng@wits.ac.za.

Thank you and I look forward to working with you

Gabrielle Katzenellenbogen

PERMISSION TO CONDUCT RESEARCH

I NICOLE KATZENELLENBOGEN the Sandton OT private practice owner understand what is required of the study and what is required of the participants in the research entitled **Vestibular function and postural control in children receiving intervention with the Astronaut Training Protocol** and agree to allow Gabrielle Katzenellenbogen, occupational therapist to work with the children, parents and teachers at SandtonOT.

Name NICOLE KATZENELLENBOGEN

Signature 

Date 07/07/2016

Appendix B

Occupational Therapist Screening Questionnaire

Code:

Child's name	
Gender	
Date of Birth	
Grade	
Therapists name	
Parents name	
Parents contact number	
Parents email address	

Please circle: Does this child display excessive in-seat movement such as fidgeting, needing movement breaks when seated at the desk.	Yes / No
Please circle: Does this child display poor posture at the desk e.g. hunches forward, leans on their arm, props neck up?	Yes / No
Please circle the below scores based on the child's assessment record according to the clinical observations assessment.	Supine flexion 1 2 3 Prone extension 1 2 3

Other comments or precautions e.g. vestibular sensitive:

Appendix C

Static Balance

Static Balance assessment edited from Movement ABC-2 (Henderson, et al., 2007)

Subject number:_____ **Date:**_____

Age:_____

ONE LEG BALANCE

Age band 1 (3-6 years)

Record time balanced in seconds. Do not administer second trial if the child maintains balance for 30 seconds. Give one practice attempt per leg for up to 15 seconds.

Right Leg		No Seconds	Left leg		No Seconds
	Trial 1			Trial 1	
	Trial 2			Trial 2	

Scoring: Must keep standing foot fixed but may keep free leg in any position as long as its off the floor and does NOT hook the standing leg. Record number of seconds up to 30. May NOT: move the standing foot, heel or toe from original position, touch free foot on the floor, or hook free leg around standing leg.

Name of item	Raw score (best attempt)	Item Standard Score	Average standard score
One-Leg Balance Best leg			
One-Leg Balance other leg			

*For Average Score: add standard score divide by 2. If result is above 10 round up; if below 10 round down

Appendix D

Postrotary Nystagmus (PRN)

Edited from Sensory Integration and Praxis Test (Ayres, 2012)

Subject number:_____ **Date: _____**

Video number: _____ **Age: _____**

Directions: The child sits cross-legged in center of nystagmus board and holds on to front edge. Head is tilted forward 30°. **"I am going to turn you around 10 times. While I'm turning you, hold your head like this. Don't move your head while you're turning. When you stop, look up and look at the wall. I will look at you, but don't you look at me; you look at the wall."** Turn child to his/her left (counterclockwise), pushing the child's left knee each time it comes around.

After completing 10 rotations in 20 seconds, stop the child so he/she is facing the wall. **"Look at the wall. Don't look at me.** (After a few seconds:) **Keep looking at the wall."** Record duration of nystagmus to nearest whole second. Be sure the time is entered as two digits (e.g., enter 6 seconds as 06).

After a 30-second rest: **"Now we'll go the other way. Keep your head this way** (position head if necessary) **and when you stop, look at the wall."** Record duration to nearest whole second. Avoid including random eye movements or secondary nystagmus in time.

After the SIPT is completed, administer this test again and record duration to the left and right.

Counterclockwise (to the left)

Number of seconds: Standard Score:

Clockwise (to the right)

Number of seconds: Standard Score

Observations:

Appendix E

Posture checklist

Subject code: _____ Date: _____

7:30 min / 9:30 min Video code: ____

Component group	Component	Place 1 next to observation
Feet and knees	**Flat on the floor. Knees at 90 degrees**	
	Feet / legs Crossed	
	Not flat on floor	
	Hooked around chair	
	Knees extended	
	Knees flexed more than 90 degrees	
	Other:	
Buttocks	**Weight bearing equally on ischial tuberosity at back of chair**	
	Weight bearing to the left	
	Weight bearing to the right	
	Sitting on edge of chair	
	Other:	
Pelvic Gridle	**Neutral**	
	Posterior tilt (sacral sitting)	
	Anterior tilt	
	Rotated	
	Other:	
Hip position	**90 degrees**	
	Hip flexion- leaning forward.	
	Hip extension- leaning back	
	Other:	
Trunk position	**Upright- shoulders above hip**	
	Trunk forwards over base	
	Trunk behind base	
	Trunk rotated to the left	
	Trunk rotated to the right	
	Trunk propped on table	
	Other:	

Shoulders	**Neutral**	
	Protracted- hunched Retracted	
	Other:	
Head alignment	**Neutral- ear in line with shoulder**	
	Pocking forwards Retracted Neck flexion more than 30 degrees Neck extension Laterally flexed to the right Laterally flexed to the left Head rotated Supported in hand / arm	
	Other:	
Arms	**Engaged in activity**	
	Non dominant arm propped on table to support body weight Non dominant arm propped on chair to support body weight	
	Other:	

TOTAL SCORE	0

Appendix F

Prone Extension Assessment

Adapted from (Gregory, 1981) (Fanchiang, 1989)

Participant Code		Video Code		Date of test	

Examiner says: "**Watch me, I am going to fly like an aeroplane**." (Examiner demonstrates and verbally executes position (i.e. head up, chest, arms up and bent at the elbows, legs straight and off the floor etc.) Examiner helps student assume position (momentarily) and instructs the student to count aloud. Examiner says: "**Now you do it by yourself**" Timing starts when the child has assumed the position. Note the time when head and / extremities touch the floor.
Judge quality of performance in the first 15 seconds (Gregory-Flock & Yerxa, 1984).

Time norms (Gregory, 1981) (Gregory-Flock & Yerxa, 1984) (Fanchiang, 1989) (Blanche, 2010)
5-8 year olds: should maintain the position for 30 seconds

1.	Duration (maximum 30 seconds)		Time:	Comments
2.	Assumption	3	Smoothly and quickly, all body parts	
		2	Segmentally	
		1	Head, hand and / knees on the mat	
3.	Head	3	Face vertical (>45°) and held steady	
		2	Face raised less than 45° or not held steady	
		1	Head on mat	
4.	Upper Trunk	3	Definite arch and elbows even with back of shoulders	
		2	Back appears flat or minimally arched, elbows forward of shoulders, fixating at shoulders	
		1	Upper trunk on mat	
5.	Thighs	3	Clearly off mat, from mid-thigh distally	
		2	Barely off, a sheet of paper can be slid under knee but not much above knees	
		1	Thighs on mat	
6.	Knees	3	Slightly bent (45° or less)	
		2	Definitely flexed (50° or more)	
		1	Knees on mat	
7.	Maintains (for full 30 seconds)	3	Moderate exertion expended- able to count without too much effort	

		2	Considerable effort / fixates at mouth, shoulders, arms, breath or moving within position.	
		1	Unable to maintain position- cannot reach age norm time	
8.	Compensatory movements- rocking, using momentum	3	None	
		2	Some rocking	
		1	Excessive rocking or use of momentum to maintain	
9.	Fixation- shoulders elevated or retracted, hands, toes	3	None	
		2	Less than 50% of the time	
		1	Fixates more than 50% of the time	

TOTAL SCORE

Appendix G

Supine Flexion Assessment

Adapted from (Fanchiang 1989)

Participant Code		Video Code		Date of test	

Examiner says: "**Watch me, I am going to curl up on my back with my legs and arms crossed**." Examiner demonstrates. "**Now lie on your back. When I say go, cross your ankles and cross your arms over your chest. Curl up, see how close you can bring your knees to your forehead. Stay that way as long as you can**." When instructions are clear say "**Go**". The position is timed as soon as extremities are lifted from the mat. Note the time when head and / extremities touch the floor.

Time norms (Fraser, 1986) (Blanche, 2010)
5 year olds: should maintain the position for 21 seconds
6 year olds: should maintain the position for 37 seconds
7 year olds: 57 seconds
8 year olds: 104 seconds

1.	Duration		Time:	Comments
2.	Assumption	3	Smoothly and quickly	
		2	Segmentally	
		1	Head or feet not lifted	
3.	Head	3	Face vertical (>45°) and held steady (chin tucked in)	
		2	Face raised less than 45° or not held steady (chin poke)	
		1	Head on mat	
4.	Upper Trunk	3	Shoulders raised at least 45°	
		2	Shoulders raised less than 45° but off floor	
		1	Shoulders remain on the floor	
5.	Buttocks	2	Buttocks clearly off the mat	
		1	Buttocks on the mat	
6.	Maintains (according to age expected time norm)	3	Moderate exertion expended- able to count without too much effort	
		2	Considerable effort - fixates at mouth, shoulders, arms, breath or moving within position,	
		1	Unable to maintain position- cannot reach age norm time	
7.	Compensatory movements-	3	None	

	rocking, using momentum			
		2	Some rocking	
		1	Excessive rocking or use of momentum to maintain	
8.	Fixation- toes, holding arms, clenching jaw , neck	3	None	
		2	Less than 50% of the time	
		1	Fixates more than 50% of the time	

TOTAL SCORE

Appendix H

Occupational Therapy Goals

M001

M001 had been in occupational therapy for two years. Occupational therapy focused on improving his vestibular processing and postural control so that he would be able to sit with better posture and reduced fidgeting at the table. Improving his vestibular, proprioceptive and tactile processing to allow for improved body awareness and praxis when completing gross motor activities. Improving rotational vestibular processing so that he will not display adverse side effects following rotational vestibular input. Improving proprioceptive and tactile input in his hands to allow for improved cutting with scissors and pencil control. Improve his visual perceptual skills and visuo-spatial planning to enable copying of numbers and letters.

M002

M002 had been in occupational therapy for eight months. Occupational therapy focused on improving his vestibular processing and postural control so that he would be able to sit at a table with appropriate posture and reduced fidgeting. Improving sensory modulation so that he could be better regulated and focused in the classroom. Improve his core muscle strength and shoulder girdle stability to allow for proximal stability to assist in improved pencil control.

M003

M003 had been in occupational therapy for three months before participating in the study. Occupational therapy focused on improving her vestibular processing and postural control to be able to sit at the table without fidgeting and displaying appropriate posture. Improving her sensory modulation so that she would not be sensitive to auditory and tactile input. Improving her sensory modulation so that she would not seek as much vestibular input and be better regulated and focused in the

classroom. Improving her bilateral coordination and sequencing so that she could participate in dance classes.

M004

M004 had been attending occupational therapy for nine months. Occupational therapy focused on improving his vestibular processing and postural control so that he would be able to sit with better posture and reduced fidgeting at the table. Improving his postural control, balance and bilateral coordination so that he could have the confidence to participate in sports activities at school. Improve vestibular, proprioceptive and tactile input so that he could have better body awareness when copying new movements. Improving his pencil grip, hand endurance and pencil control so that he could colour inside the lines. Improve his visuo-praxis so that he could copy letters and numbers.

M005

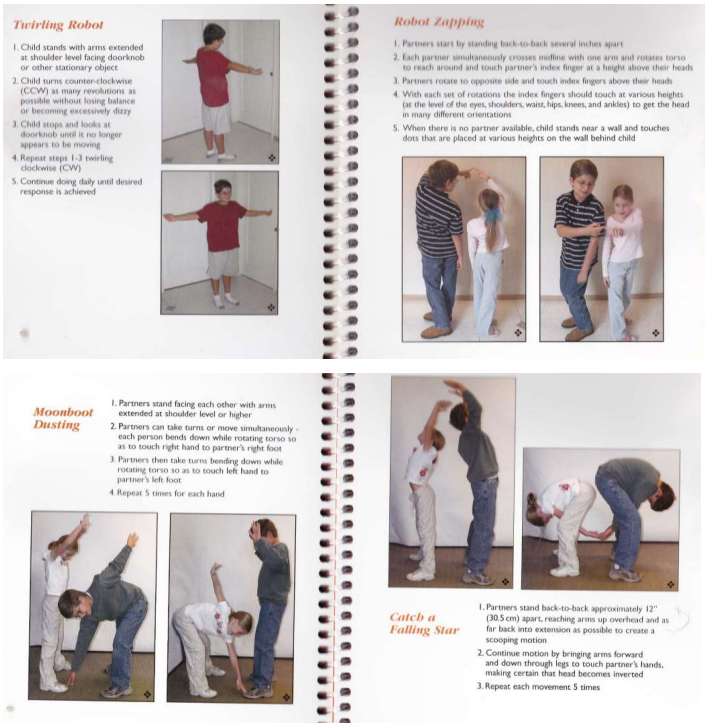
M005 had been attending occupational therapy for 10 months before participating in the research. Occupational therapy focused on improving his vestibular processing and postural control so that he would be able to sit with improved posture and reduced fidgeting at the table. Improving his body awareness, core muscle strength, balance and bilateral coordination and sequencing so that he could participate and learn new skills in soccer. Improving his visuo-praxis so that he can copy letters and numbers in class.

Appendix I

Astronaut Training Protocol (Kawar, et al., 2005)

The creator of the Astronaut Training Protocol (Mary Kawar) (Kawar, et al., 2005) was consulted telephonically regarding the implementation of the programme. The Astronaut Training is divided into four stages- preparation, rotation, eye movements and linear movement.

The Preparation stage involved four activities (see pictures below): “Twirling Robot”- spinning in standing with the arms extended at shoulder level and palms facing upwards. “Robot Zapping”- standing with feet hip-width apart and back to back with the researcher. Each partner simultaneously crossed their midline with one arm and rotated their torso to reach around and touch the partner’s index finger at various heights. “Moonboot dusting”- Researcher and participant stood facing each. The participant bent down while rotating the torso so as to touch the right hand to the researcher’s right foot, returned to standing and repeat with the opposite arm. “Catching a falling star”- Researcher and participant stood back-to-back, both reached arms up overhead as far back into extension as possible and then brought arms forward and down through the legs to touch each other’s hands.



The Rotation stage involved the child sitting with legs crossed on the Astronaut Training Board with head tilted forwards by 30 degrees. This allowed for activation of the horizontal semi-circular canal. The child was spun up to 10 revolutions in time to the beat of the music (1 revolution per 2 seconds). This depended on their tolerance of rotation - more sensitive children were spun fewer revolutions. Saccadic and smooth pursuit eye movements follow rotatory input and were done in time to the music using penlights. This was done in sitting (spinning then eye movements) and then repeated in side lying. When positioned in side lying, the child placed the head on the arm to maintain spinal alignment and the head was turned so that the nose was orientated 45 degrees off midline towards the support surface. This allowed for activation of the superior and posterior semi-circular canals.


Sitting with proper head alignment for rotation


Position for left side-lying rotations


Sitting

The Eye Movement stage involved a combination of eye movements (two exercises were chosen and changed at each session) – diagonal saccadic movements; figure of eight; horizontal, vertical and circular head movements; convergence and divergence and peripheral vision.

The Linear Stage involved a variety of activities (two were chosen) that required linear vestibular input and proprioceptive input. The activities specifically looked at supine flexion and prone extension positions and were individually adapted to each child depending on their abilities. Activities using a hammock swing and scooter board were chosen. Prone extension activities included: lying in prone on a scooter board and pushing off a wall with their hands. Lying in prone on a scooter board and holding a bungee cord to pull forwards and backwards whilst looking at visual targets on the floor. Lying in prone in a hammock with the hammock positioned under their armpits and mid-thigh, swinging to fetch beanbags placed on the floor

and throw to a target about 2 meters away. Supine flexion was stimulated by lying in supine on a scooter board and kicking off a wall. Lying in supine on a scooter board and pulling a bungee cord to move their body forward and backwards. Lying in supine in the hammock with the hammock positioned from the scapulae to their mid-thigh with beanbags placed on the stomach, the child has to flex their neck to throw beanbags and aim to a target.

Signs of sensory overload including yawning, changes in skin colour, headache, changes in respiration rate or heart rate, pupil dilation, prolonged dizziness and nausea. Sensory overload was more likely to occur during rotation than linear movement.

How to deal with sensory overload- Active, intense proprioceptive activities were done such as placing hands on their head, sucking in their cheeks and jumping, place ice cubes in the child's palm of their hands, temples and base of the skull, placing their body into soft mattresses and pushing their body as hard as possible.

Appendix J

Astronaut Training Observations

Code:_____ Activity	Observations			
	Date:	Date:	Date:	Date:
Twirling Robot				
Robot Zapping				
Moonboot Dusting				
Catching a falling star				
Rotation in sitting	CCW			
	CW			
Horizontal saccades	Rapid			
	Slow			
Horizontal smooth pursuits	Rapid			
	Slow			
Rotation in Side lying on Left	CCW			
	CW			
Rotation in Side lying on right side	CCW			
	CW			
Vertical saccadic eye movements	Rapid			
	Slow			
Vertical smooth pursuit eye movements	Rapid			
	Slow			
Linear activity: scooter board; hammock				

Appendix K

INFORMATION SHEET PARENTS/CAREGIVERS

Study title: Vestibular function and postural control in children receiving intervention with the Astronaut Training Protocol

Good day,

Introduction:
My name is Gabrielle Katzenellenbogen and I am a sensory integration trained occupational therapist. I am currently doing research for an MSc degree in occupational therapy at the University of the Witwatersrand. I am doing research on an intervention programme- the Astronaut Training Protocol. This programme facilitates the integration of the vestibular (movement), visual and auditory systems. Little research has been done on this programme although it appears to be effective in changing function in children with sensory integration dysfunction. I am completing a study that will investigate the impact of the Astronaut Programme on a child's posture and their in-seat behaviour at the desk.

Permission:
I am inviting you and your child to participate in this study

What is involved in the study:

The study will take place over 12 occupational therapy sessions. The child will be assessed at the end of the study and a 1 minute assessment of prone extension (lying on their stomach and lifting up their head, legs and arms) and supine flexion (lying on their back and rolling into a ball) will be completed on them during each of their regular occupational therapy sessions over four sessions. Control in these positions helps identify the vestibular function and will provide a baseline of how the child is functioning. I am requesting that another occupational therapist at the practice assist with some of the assessments and video record them as this will allow for an unbiased assessment.

For the next four sessions, I will add sessions of Astronaut Training for your child who will again be assessed after every session using the prone extension and supine flexion positions. In the last four sessions once the Astronaut Training is finished your child will be assessed for one minute after their routine occupational therapy to determine if the programme has had a carryover.

I will be available to present the Astronaut Training programme at a time convenient for you and your child. Your child will need to receive eight Astronaut Training sessions for approximately 20 minutes each session.

The Astronaut Training involves doing a variety of activities to music such as spinning on a rotation board, eye movement exercises as well as linear exercises such as swinging in the

hammock swing or using a scooter board. Your child will still receive their regular occupational therapy sessions over this period.

The effectiveness of the programme will be measured by videoing the child's posture in the therapy room during a 10-minute table-top activity, as well as in-seat movement using an accelerometer. An accelerometer is a small device that is worn around the child's waist and measures the amount of energy used during movement. These assessments along with a balance test, PRN (spinning test) will be done on sessions 1, sessions 4, sessions 8 and sessions 12.

Risks:
Some risks involved in the study are the child may be sensitive to vestibular input and may feel nauseous after the programme. Each child will be carefully monitored for signs of overstimulation to prevent this from happening. The programme will be adapted for each child depending on their difficulties and sensory profile.

Meeting
An information meeting or telephone call will be arranged prior to the study taking place to explain the study and possible side effects involved. This will be arranged at your convenience.

Benefits of being in the study
This intervention will be an "add on" to therapy. This study may benefit the child as they will receive therapy specifically focusing on their vestibular processing. This intervention may assist the children in other areas of difficulty such as posture and visual tracking.

Feedback:
Parents will be given feedback regarding important information during the study via email and the results will be made available after the study.

Participation:
Participation is voluntary and if you or your child refuses to participate in the study or decide to discontinue during the study, there will be no penalty, and this will not affect the child's therapy in any way. All children will be asked if they wish to participate and will not be included in the study if they are unwilling to do so.

Confidentiality:
Efforts will be made to keep personal information confidential. Your child will receive a code which will be kept separate from their names to ensure confidentiality. Videos will be stored on a password-protected computer and only deleted after six years according to HPCSA regulations.

Contact details:
For more information, you can contact Gabbi at gabbikatz@gmail.com or 0826777898

Contact details of REC administrator and chair – for reporting of complaints /
If you have any questions, you can contact me on 082 677 7898. Ethical clearance has been obtained (M 170522). For any ethical concerns please contact the chairperson of the Human

Research Ethics Committee at the University of Witwatersrand, Prof P Cleaton-Jones at peter.cleaton-jones@wits.ac.za. Contact details for the administrative offices: Ms. Z Ndlovu/ Mr Rhulani Mkansi/ Mr Lebo Moeng, Tel: 011 717 2700/2656/1234/1252, or email: Zanele.ndlovu@wits.ac.za; Rhulani.mkansi@wits.ac.za; Lebo.moeng@wits.ac.za.

Thank you and I look forward to working with you

Gabrielle Katzenellenbogen

INFORMED CONSENT SHEET

I, (print name) _____the parent /caregiver of _____ understand what is required of the study and what is required of the participants in the research entitled **Vestibular function and postural control in children receiving intervention with the Astronaut Training Protocol** and agree to Allow my child to take part in the study

It has been explained that the participant's confidentiality will be ensured as names will not be included in the reporting of the results and no information from the assessments will be divulged.

Name _____

Signature _____

Date _____

INFORMED CONSENT FOR CHILD TO BE VIDEOED

I, (print name) _____the parent /caregiver of _____ understand what is required of the study and what is required of the participants in the research entitled **Vestibular function and postural control in children receiving intervention with the Astronaut Training Protocol** and agree allow my child to be videoed as part of the research.

Name _____

Signature _____

Date _____

BACKGROUND QUESTIONNAIRE

Child's name:_____
Child's date of birth:_____

Does your child have any of the following difficulties processing vestibular input (movement)? Please circle

Gets car sick or motion sick?	Yes	No
Avoids swings	Yes	No
Dislikes lifts or elevators	Yes	No
Scared of heights	Yes	No
Becomes over excited during movement such as swings, trampolines or spinning	Yes	No
Seeks a lot of movement that interferes with his/ her daily routine such as can't sit still, fidgets, rocks in the chair	Yes	No

If you circled yes, please comment below:

_____
_____
_____

Appendix L

INFORMED ASSENT

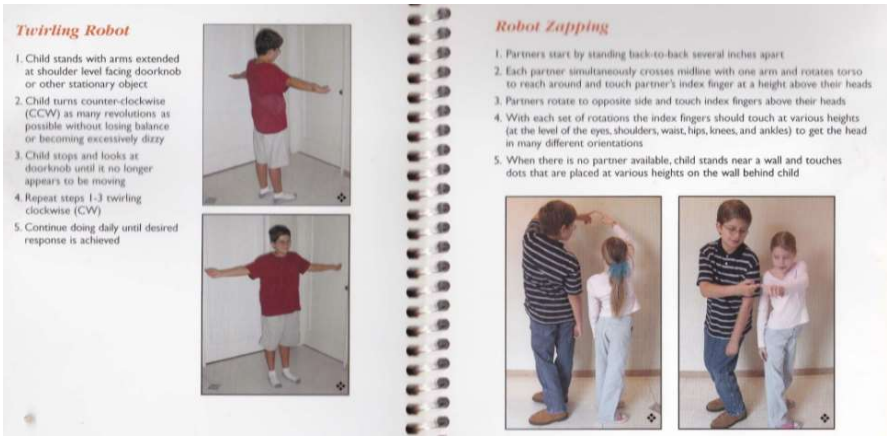
Study title: Vestibular function and postural control in children receiving intervention with the Astronaut Training Protocol

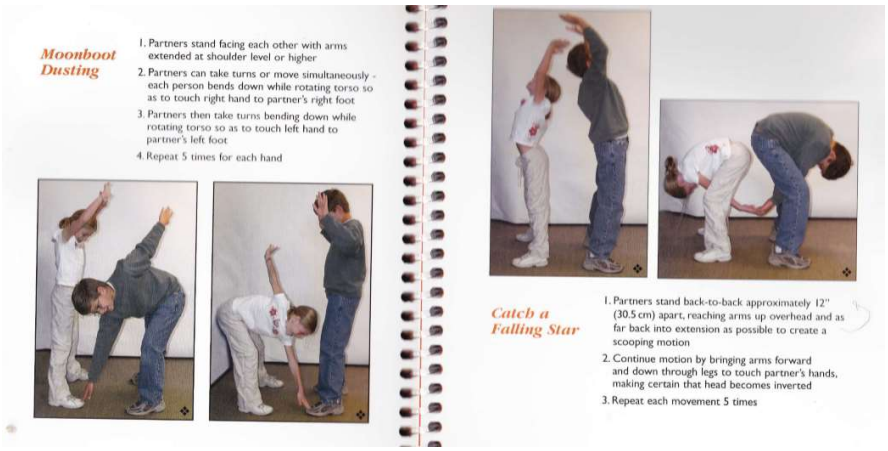
Greeting and Introduction
My name is Gabbi and I am an occupational therapist and I would like to conduct a study at your occupational therapy practice that would involve your participation. I am doing research on a programme called the Astronaut Training Programme. I want to see if this programme will help how you sit at your desk.

Invitation to participate
I would like to invite you to participate in the following study. If you say yes to participate in the study the following will take place:

The study will take place over 12 sessions. You will be assessed at the start of the study and a 1 minute assessment of prone extension (lying on your stomach and lifting up your head, legs and arms) and supine flexion (lying on your back and rolling into a ball) will be completed during each of your regular occupational therapy sessions over four sessions. These assessments will be videoed.

For the next four sessions, I will add sessions of Astronaut Training (you will still have your weekly OT sessions). The Astronaut Training sessions will be twice per week and about 20 minutes long. This involves preparation activities (see below)





Moonboot Dusting

1. Partners stand facing each other with arms extended at shoulder level or higher
2. Partners can take turns or move simultaneously - each person bends down while rotating torso so as to touch right hand to partner's right foot
3. Partners then take turns bending down while rotating torso so as to touch left hand to partner's left foot
4. Repeat 5 times for each hand

Catch a Falling Star

1. Partners stand back-to-back approximately 12" (30.5 cm) apart, reaching arms up overhead and as far back into extension as possible to create a scooping motion
2. Continue motion by bringing arms forward and down through legs to touch partner's hands, making certain that head becomes inverted
3. Repeat each movement 5 times

Using a spinning board (PRN board) and spinning in sitting and side lying as well as looking at torches to do eye exercises. (see below)



Sitting with proper head alignment for rotation



Position for left side-lying rotations



Sitting

We will then go into the OT room and play on the hammock swing or scooter board. At the end of the session, I will assess your supine flexion and prone extension positions and video record them.

To see if the Astronaut Training sessions are successful, I will video you sitting at the table doing an activity for 10 minutes as well as using an accelerometer to measure your in-seat movement. An accelerometer is a small device that is worn around your waist and measures the amount of energy used during movement. These assessments along with a balance test, PRN (spinning test) will be done on session 1, session 4, session 8 and session 12 by another occupational therapist.

Risks:
Some risks involved in the study are you may be sensitive to spinning and may feel nauseous after the programme. I will carefully monitor you for signs of overstimulation to prevent this from happening. If you feel nauseous, dizzy or have a headache, please let me know.

You can say NO if you feel that you don't want to take part in the study. You can also decide to no longer participate in the study at any time throughout the process of conducting this research and this will not impact you negatively in any way.

You can ask me/us any questions at any time.

SIGNED INFORMED ASSENT

I _____ agree to participate in the study and understand the treatment and assessment procedure.

I understand that participation is voluntary, and I can withdraw at any time.

Date: _____

Signature: _____

Witness: _____

SIGNED INFORMED ASSENT TO BE VIDEOED

I _____ agree to be videoed in the study and understand the treatment and assessment procedure.

I understand that participation is voluntary and I can withdraw at any time.

Date: _____

Signature: _____

Witness: _____

Appendix M

R14/49 Miss Gabrielle Katzenellenbogen

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M170522

NAME: (Principal Investigator)	Miss Gabrielle Katzenellenbogen
DEPARTMENT:	Occupational Therapy Bellavista School
PROJECT TITLE:	Vestibular Function and Postural Control in Children Receiving Intervention with the Astronaut Training Protocol
DATE CONSIDERED:	26/05/2017
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Denise Franzsen and Janine van der Linde
APPROVED BY:	Professor CB. Penny Co-Chairperson, HREC (Medical)
DATE OF APPROVAL:	31/08/2017

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary in Room 10004,10th floor, Senate House/3rd floor, Philip Tobias Building, Parktown, University of the Witwatersrand. I/We fully understand the conditions under which I am/we are authorised to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. in this case, the study was initially review May and will therefore be due in the month of May each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature Date

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Appendix N

Turnitin Originality Report

VESTIBULAR FUNCTION AND POSTURAL CONTROL IN CHILDREN RECEIVING INTERVENTION WITH THE ASTRONAUT TRAINING PROTOCOL.

by Gabrielle Katzenellenbogen

FILE	112_GABRIELLE_KATZENELLENBOGEN_VESTIBULAR_FUNCTION_AND_POSTURAL_CONTROL_IN_CHILDREN_RECEIVING_INTERVENTION_WITH_THE_ASTRONAUT_186141399.DOCX (46)		
TIME SUBMITTED	17-FEB-2019 05:16PM (UTC+0200)	WORD COUNT	23414
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VESTIBULAR FUNCTION AND POSTURAL CONTROL IN CHILDREN RECEIVING INTERVENTION WITH THE ASTRONAUT TRAINING PROTOCOL.

ORIGINALITY REPORT

%2	%1	%1	%
SIMILARITY INDEX	INTERNET SOURCES	PUBLICATIONS	STUDENT PAPERS

PRIMARY SOURCES

1	Shelley Mulligan. "Validity of the Postrotary Nystagmus Test for Measuring Vestibular Function", OTJR: Occupation, Participation and Health, 2010 Publication	<%1
2	scholar.ufs.ac.za:8080 Internet Source	<%1
3	Huang, San-Yuan, Ming-Teng Lin, Wei-Wen Lin, Cheng-Chang Huang, Mee-Jen Shy, and Ru-Band Lu. "Association of monoamine oxidase A (MAOA) polymorphisms and clinical subgroups of major depressive disorders in the Han Chinese population", The World Journal of Biological Psychiatry, 2009. Publication	<%1
4	www.scribd.com Internet Source	<%1
5	etheses.whiterose.ac.uk	