

**EYE MOVEMENTS AND POSTURAL
ALIGNMENT IN CHILDREN WITH CEREBRAL
PALSY**

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DECLARATION

I, CHRISTINA ELIZABETH SCHOLTZ, certify that the dissertation hereby submitted by me for the **M Occupational Therapy** degree at the University of the Free State is my independent effort and had not previously been submitted for a degree at another university/faculty. I furthermore waive copyright of this dissertation in favour of the University of the Free State.

Christina E. Scholtz

Date

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TABLE OF CONTENTS

Eye movements and postural alignment in children with Cerebral Palsy

DECLARATION	ii
ACKNOWLEDGEMENTS	iii
TABLE OF CONTENTS	iv
LIST OF TABLES	vii
LIST OF FIGURES	viii
LIST OF ABBREVIATIONS	ix
CONCEPT CLARIFICATION & DEFINITIONS	xi
SUMMARY	xii
OPSOMMING	xiv
CHAPTER 1 INTRODUCTION AND ORIENTATION TO THE STUDY	1
1.1 INTRODUCTION	1
1.2 PROBLEM STATEMENT	8
1.2.1 Aim	9
1.2.2 Objectives	9
1.3 METHODOLOGY	10
1.4 THE VALUE AND EXTENT OF THE STUDY	11
1.5 ETHICAL CONSIDERATIONS	11
1.6 CHAPTER EXPLANATION AND OUTLINE	11
1.7 SUMMARY	12
CHAPTER 2 LITERATURE STUDY	13
2.1 INTRODUCTION	13
2.2 WORLD HEALTH ORGANISATION	14
2.2.1. Functional Vision	16
2.3 CEREBRAL PALSY	17
2.3.1 Epidemiology and Risk Factors	18
2.3.2 Definition of Cerebral Palsy.....	19
2.3.3 Classification.....	20
2.3.4 Pathophysiology of Cerebral Palsy	21
2.4 BOBATH/NEURO-DEVELOPMENTAL TREATMENT APPROACH	23
2.5 RELATIONSHIP BETWEEN POSTURE, MOVEMENT, STABILITY AND FUNCTION	23
2.6 POSTURAL CONTROL	24
2.6.1 Postural Orientation for Sitting	25
2.6.2 Postural Stability in Sitting	28

2.6.3 Motor Milestones and Emerging Postural Control for Sitting	28
2.6.4 Implications of Cerebral Palsy	30
2.6.5 Sensory Contributions.....	31
2.7 VISUAL PROCESSING SYSTEM/ FUNCTIONAL VISION	32
2.7.1 The Eye as an Optical System.....	33
2.7.2 Visual Pathways.....	34
2.7.3 The Ocular Motor System.....	41
2.7.4 Implications for Cerebral Palsy.....	48
2.8 CHAPTER SUMMARY.....	50
CHAPTER 3 RESEARCH APPROACH AND METHODOLOGY	51
3.1 INTRODUCTION	51
3.1.1 Aim of The Study.....	51
3.1.2 Objectives	52
3.2 RESEARCH APPROACH AND STUDY DESIGN	52
3.3 METHODOLOGY	53
3.3.1 Study Population and Sampling	53
3.4 DATA COLLECTION	54
3.4.1 The Data Collection Process	56
3.4.2 Measurement Instruments	57
3.4.3 Data Analysis	63
3.4.4 Pilot Study.....	64
3.4.5 Errors of Measurement.....	65
3.5 ETHICAL CONSIDERATIONS	66
3.5.1 Ethical Clearance and Permission.....	66
3.5.2 Avoidance of Harm.....	67
3.5.3 Informed Consent.....	67
3.6 CHAPTER SUMMARY.....	68
CHAPTER 4 RESULTS.....	70
4.1 INTRODUCTION	70
4.2 CHARACTERISTICS OF CEREBRAL PALSIED CHILDREN	70
4.2.1 Age Group.....	71
4.2.2 Classification of Cerebral Palsy	72
4.2.3 Accompanied Impairments	72
4.2.4 Therapeutic Interventions	73
4.2.5 Medical Examinations.....	74
4.2.6 Medication	75
4.2.7 Unstructured Observation for Eye Contact, Head Control and Upper-Extremity Use.....	75
4.2.8 Motor Milestones	76
4.3 VISUAL BEHAVIOUR CHARACTERISTICS; PERTAINING TO PARTICIPANTS WITH CEREBRAL PALSY	80
4.3.1 Appearance	82
4.3.2 Vision Function.....	82
4.3.3 Mobility Skills	82
4.3.4 Improved Visual Performances.....	82
4.4 EYE MOVEMENTS	83
4.5 POSTURAL ALIGNMENT IN SITTING IN THE FRONTAL PLANE.....	85

4.6 THE ASSOCIATION BETWEEN EYE MOVEMENTS AND POSTURAL ALIGNMENT IN SITTING IN THE FRONTAL PLANE OF CHILDREN WITH CEREBRAL PALSY BETWEEN THE AGES OF TWO - TEN YEARS	86
4.6.1 Two-Way Frequencies Tables.....	86
4.6.2 Spearman Correlation Coefficient.....	91
4.7 CHAPTER SUMMARY	92
CHAPTER 5 DISCUSSION OF RESULTS	93
5.1 INTRODUCTION	93
5.2 CHARACTERISTICS OF CHILDREN WITH CP	93
5.2.1 Age Group.....	94
5.2.2 Classification.....	94
5.2.3 Accompanied Impairments	95
5.2.4 Therapeutic Interventions	96
5.2.5 Medical Examinations and Investigation	97
5.2.6 Medication	99
5.2.7 Unstructured Observation for Eye Contact, Head Control and Upper-Extremity Use.....	99
5.2.8 Visual Behaviour Characteristics	106
5.2.9 Eye Movements	106
5.2.10 Postural Alignment	113
5.2.11 The Spearman Correlation Coefficient	114
5.3 CHAPTER SUMMARY	115
CHAPTER 6 CONCLUSIONS, RECOMMENDATIONS AND LIMITATIONS	116
6.1 INTRODUCTION	116
6.2 LIMITATION	116
6.3 CONCLUSIONS.....	117
6.4 RECOMMENDATIONS AND IMPLICATIONS FOR CLINICAL PRACTICE	118
6.5 TO CONCLUDE	120
REFERENCE LIST.....	121
APPENDICES	142
APPENDIX A	143
APPENDIX B	149
APPENIX C.....	154

LIST OF TABLES

TABLE 3.1: SUMMARY OF RESEARCH METHODOLOGY	51
TABLE 3.2: OVERVIEW OF MEASUREMENT INSTRUMENTS, -METHODS AND REASONS	56
TABLE 3.3: CHARACTERISTICS OF THE PARTICIPANT	59
TABLE 3.4: DATA COLLECTION RELATING TO EYE CONTACT, HEAD CONTROL AND UPPER-EXTREMITY	60
TABLE 3.5: DESCRIPTION OF MILESTONES REACHED.....	61
TABLE 3.6: VISUAL BEHAVIOUR DURING EYE MOVEMENTS	61
TABLE 3.7: CHARACTERISTICS OF CEREBRAL VISUAL IMPAIRMENT	62
TABLE 3.8: POSTURAL ALIGNMENT IN SITTING	63
TABLE 3.9: METHODOLOGICAL AND MEASUREMENT ERRORS.....	66
TABLE 4.1: AGES OF THE CHILDREN (N=55)	71
TABLE 4.2: SUB-TYPES OF CEREBRAL PALSY (N=57)	72
TABLE 4.3: ACCOMPANIED IMPAIRMENTS (N=23)	73
TABLE 4.4: PREVIOUS TREATMENTS RECEIVED (N=39).....	73
TABLE 4.5: MEDICAL EXAMINATION AND INVESTIGATION (N=32).....	74
TABLE 4.6: PRESCRIBED MEDICATION (N=30).....	75
TABLE 4.7: UNSTRUCTURED OBSERVATIONS FOR EYE CONTACT, HEAD CONTROL AND UPPER-EXTREMITY USE (N=57).....	76
TABLE 4.8: MILESTONE: EYE CONTACT MASTERED (N=43)	77
TABLE 4.9: MILESTONES: HAND REGARD MASTERED (N=33)	78
TABLE 4.10: MILESTONES- HANDS TO MIDLINE MASTERED (N=29).....	78
TABLE 4.11: MILESTONES: ROLLING MASTERED (N=29)	79
TABLE 4.12: MILESTONES: SITTING INDEPENDENTLY (N=23).....	79
TABLE 4.13: UNSTRUCTURED OBSERVATIONS FOR VISUAL BEHAVIOUR (N=57)	81
TABLE 4.14: EYE MOVEMENTS (N=57)	83
TABLE 4.15: STRUCTURED OBSERVATION FOR POSTURAL ALIGNMENT IN SITTING ON A BENCH (N=57)	85
TABLE 4.16: FREQUENCIES OF POSTURAL ALIGNMENT AND FIXATION (N=57)	87
TABLE 4.17: FREQUENCIES OF POSTURAL ALIGNMENT AND FOLLOWING (N=57)	88
TABLE 4.18: THE TWO-WAY FREQUENCY OF POSTURAL ALIGNMENT AND SACCADES.....	88
TABLE 4.19: FREQUENCIES OF POSTURAL ALIGNMENT AND VISUAL RESPONSE TO PERIPHERAL STIMULUS (N=57)	89
TABLE 4.20: FREQUENCIES OF POSTURAL ALIGNMENT AND PUPILLARY RESPONSE (N=57).....	90
TABLE 4.21: FREQUENCIES OF POSTURAL ALIGNMENT AND NYSTAGMUS (N=57)	91
TABLE 4.22: THE SPEARMAN CORRELATION COEFFICIENTS (N=57).....	92

LIST OF FIGURES

FIGURE 4.1: MILESTONES REACHED (N=44).....	77
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LIST OF ABBREVIATIONS

CNS	Central nervous system
CP	Cerebral palsy
CT	Computerized Tomography
CVI	Cerebral visual impairment
EEG	Electroencephalogram
ECUFS	Ethics Committee of the University of the Free State
GMFCS	Gross Motor Function Classification System
ICF	International Classification of Functioning, Disability and Health
ICF-CY	International Classification of Functioning, Disability and Health-Children and Youth Version
LGN	Lateral geniculate nuclei/bodies
MRI	Magnetic Resonance Imaging
NDT	Neuro-Development Treatment/ Bobath
OKN	Optokinetic nystagmus
OT	Occupational Therapist
OTs	Occupational Therapists
OTPF	Occupational Therapy Practice Framework
PT	Physical Therapist
PVL	Periventricular Leucomalacia
SACND	The sitting assessment for children with neuromotor dysfunction
SPCE	Surveillance of Cerebral Palsy in Europe

ST	Speech Therapist
ROP	Retinopathy of prematurity
VEP	Visual Evoked Potential
VOR	Vestibulo Ocular Reflex
V1	Visual Areas and spatial summation in human visual cortex
WHO	World Health Organization

CONCEPT CLARIFICATION & DEFINITIONS

Cerebral visual impairment: In this study cerebral visual impairment will be used as the term encompasses a wider range of disorders, including visual disturbance on account of oculomotor incoordination, visual, cognitive, and perceptual impairment owing to pathology affecting the visual association cortices and their interconnecting pathways (Roman-Lantzy 2007:2/14).

Functional vision: Functional vision describes how the person functions in vision-related tasks in terms of sustainable visual performance (Dutton 2008:15). The term applies to skills and abilities and, in children, to the acquisition of these skills. These skills are needed during activities of daily living, orientation and mobility, sustained vision tasks, communication and interaction (Hyvärinen 2010:266).

Habilitative: The term is chosen in preference to rehabilitative because in most children with cerebral palsy no function has been lost to rehabilitate (Dutton & Bax 2010:1).

Ocular visual impairments are the deficits resulting from disorders of visual input caused by ocular or optic nerve disorder (Stolk, Arentz & Sterkenburg 2008:18).

Visual dysfunction applied to impaired visual ability. The term is used when the child's visual functioning is not just limited due to insufficient input to the brain, but is also abnormal because of defective processing of visual information in the brain (Scheiman 1997:42).

Vision for function (Visual function): Describes how the eyes and the basic visual system function in terms of threshold visual performances (Atkinson 2002:15). Visual fields, acuity and contrast are tested one at a time (Colenbrander 2010:285).

Visual impairment: Describes a lack of one or more visual functions and can be related to ocular visual impairment or cerebral visual impairment (Roman-Lantzy 2007:2/32).

SUMMARY

KEYWORDS: Cerebral Palsy, Postural Alignment, Postural Control, Eye Movements, Functional Vision, Cerebral Visual impairment, Visual Pathways, Visual Dysfunction, Participation, Occupational-based activities.

The level of severity of disability may have increased among children with cerebral palsy and therefore continued monitoring of the characteristics of children with cerebral palsy is necessary. Cerebral palsy (CP) can be considered as a sensory-motor disorder that results from malformations in the developing brain that disrupts the development of the neuronal network and cortical and sub-cortical pathways. Although the motor behaviours and postural deficits are defining features of CP, visual disorders are a main symptom in the clinical picture of CP.

There are well sounded reasons why children with CP have difficulties to partake in everyday activities. Neurologic pathology can affect specific aspects of postural control including the ability to maintain stability with alignment in a specific position. Postural control is necessary for maintaining all body segments in an upright position and to orientate the eyes to the environment. Problems with the visual system in CP include peripheral problems related to the anterior part of the visual system, visual problems of central origin and cerebral visual impairment. Observations of eye movements and postural alignment in sitting in children with CP were the focus of this study. These are variables known to potentially influence occupational-based activities.

The aim of the study was to describe eye movements and postural alignment and to investigate if there was a possible association between eye movements and postural alignment in sitting in a frontal plane of children with CP, between the age of two and ten years.

A non-experimental, quantitative approach addressed the aim. A descriptive study was used to describe the eye movements and alignment in body segments over the base of support against gravity. A correlation study was used to investigate the possible association between postural alignment and eye movements in children with CP. Following the pilot study the unstructured and structured observations were administered to a convenience sample of children with CP attending a clinic, school or a private practice. Fifty seven children with CP, between two and ten years of age

participated in the study after meeting the pre-determined inclusion criteria. The data collected were numbers that reflected specific measurements of the characteristics in question and were analysed by using a grounded, observed – clinical reasoning approach.

The mean age of the children was 5.3 years (SD = 2.26). Discussion of results was directed at describing eye movements and postural alignment and interpreting the implications of those associations for clinical practice. The obtained data from the unstructured and structured observations were statistically analysed and compared and did produce a statistically significant positive association between eye movements and postural alignment therefore, both the posture and the eye movements are critical to the provision of intervention.

The study confirms the association between eye movements and postural alignment in sitting in children with CP. This study has documented the difficulties the child with CP has to encounter. This may facilitate the establishment of effective and appropriate measuring instruments for occupational therapists, assessing functional vision and postural alignment in any setting of practice.

OPSOMMING

SLEUTELWOORDE: Serebrale Gestremdheid, Postuurbelyning, Postuurbeheer, Oogbewegings, Funksionele Visie, Serebraal-Visuele Inkorting, Visuele Bane, Visuele Disfunksie, Deelname, Beroepsgebaseerde Aktiwiteite.

Die erns van simptome van gestremdheid neem toe onder kinders met serebrale gestremdheid en die voortgesette monitering van die eienskappe van kinders met serebrale gestremdheid is nodig. Serebrale gestremdheid (SG) kan beskou word as 'n sensories-motoriese disfunksie wat voortspruit uit misvormdhede in die ontwikkelende brein wat die ontwikkeling van neurale netwerke en kortikale en subkortikale bane versteur. Alhoewel die motoriese gedrag en postuurtekorte 'n definiërende eienskap van SG is, is visuele disfunksies 'n primêre simptoem van die kliniese beeld van SG.

Daar bestaan weldeurdagte redes waarom kinders met SG dit moeilik vind om aan alledaagse aktiwiteite deel te neem. Neurologiese patologie kan spesifieke aspekte van postuurbeheer affekteer, insluitende die vermoë om stabiliteit in 'n spesifieke posisie te handhaaf. Postuurbeheer is nodig vir die handhawing van alle liggaamsegmente in 'n regop posisie en om die oë ten opsigte van die omgewing te oriënteer. Probleme met die visuele sisteem in SG sluit perifere probleme met betrekking tot die voorkant van die visuele sisteem, visuele probleme van sentrale oorsprong en serebraal-visuele inkorting in. Waarnemings rakende oogbeweging, postuurbelyning in 'n sittende posisie en oogbeweging by kinders met SG was die fokus van hierdie studie. Dit is bekend dat hierdie veranderlikes potensieel beroepsgebaseerde aktiwiteite beïnvloed.

Die doel van die studie was om oogbewegings en postuurbelyning te beskryf en ondersoek in te stel of daar 'n moontlike assosiasie tussen oogbewegings en postuurbelyning in 'n vooraansig by kinders met SG in 'n sittende posisie tussen die ouderdom van twee en tien jaar is.

'n Nie-eksperimentele, kwantitatiewe benadering het die doelwit aangespreek. 'n Beskrywende studie is gebruik om die oogbewegings en postuurbelyning in liggaamsegmente oor die steunbasis teen swaartekrag te beskryf. 'n Korrelasiestudie is gebruik om die moontlike assosiasie tussen postuurbelyning en oogbewegings by kinders met SG te ondersoek. Na afloop van die loodsstudie is die ongestruktureerde en gestruktureerde waarnemings op 'n gerieflikheidssteekproef van kinders met SG wat 'n

kliniek, skool of private praktyk besoek, gedoen. Sewe-en-vyftig kinders met SG tussen die ouderdom van twee en tien jaar het aan die studie deelgeneem, nadat hulle aan die voorafbepaalde insluitingskriteria voldoen het. Die data wat versamel is, is getalle wat spesifieke metings van die eienskappe in die vroeë weerspieël en geanaliseer is deur van 'n begroede, waargenome, kliniese beredeneringsbenadering gebruik te maak.

Die gemiddelde ouderdom van die kinders was 5,3 jaar ($SD = 2.26$). Die bespreking van die resultate was daarop gemik om oogbewegings en postuurbelyning te beskryf en die implikasies van daardie assosiasies vir die kliniese praktyk te vertolk. Die data wat uit die gestruktureerde waarnemings verkry is, is statisties ontleed en vergelyk en het 'n statisties betekenisvolle positiewe verband tussen oogbewegings en postuurbelyning aangetoon. Gevolglik is beide die postuur- en oogbewegings krities wat betref enige intervensie.

Die studie bevestig die assosiasie tussen oogbewegings en postuurbelyning by kinders met SG in 'n sittende posisie. Hierdie studie het die probleme gedokumenteer waarmee 'n kind met SG gekonfronteer word. Dit kan die vestiging van doeltreffende en geskikte meetinstrumente vir arbeidsterapeute fasiliteer wat funksionele visie en postuurbelyning in enige omgewing kan assesseer.

CHAPTER 1

INTRODUCTION AND ORIENTATION TO THE STUDY

1.1 INTRODUCTION

This chapter demonstrates the researcher's clinical reasoning for conducting this study, striving to describe, analyse and interpret postural alignment and eye movements in children with cerebral palsy and whether any association exist between these two variables in order to continue the journey as occupational therapists (OTs) to best practice. This study is based on the researcher's theoretical knowledge and practical experiences in the clinical setting and the many questions that have arisen from this setting.

Children develop occupations through participation in family and cultural practices, learning to become full participants in the community (Case-Smith 2010b:63). Early childhood is characterised by the development of increased independence (Dodd & Greaves 2010:96), which can be described as the ability to perform everyday activities according to family and cultural practices (Case-Smith 2010b:63; Creek 2010:126). The levels of independence, safety and adequacy of occupational performance of the child and family determine the child's activities of daily living in various contexts (Shepherd 2010:474). The importance of mastering daily activities was emphasised by Henderson and Eliasson (2008:320) in their statement that the mastery of self-care increases a child's control of both home and school environments, freeing the child from dependence on the convenience of caregivers. Engagements in tasks, activities or occupations are made possible through interaction of systems, higher level processes and environment and are essential to predictive and adaptive control of movement (O'Brien & Williams 2010:264, Youngstrom 2002:608). In contrast, children with cerebral palsy are limited in their activity performance and participation due to a myriad of factors which will influence the cerebral palsied child's involvement in life situations (Beckung & Hagberg 2002:309; Chiarello, Palisano, Barlett & Westcott-McCoy 2011:150).

The term 'cerebral palsy' (CP) was originally introduced and popularised in the writings of Sir W. Osler (1889/1987), one of the founding fathers of modern medicine (Pellegrino & Dormans 1998:4). Osler's strong interest in pathology and the pathophysiology is evident in his treatment of CP. According to Pellegrino and Dormans (1998:5) the second half of the 20th century witnessed three main developments. Firstly to determine the prevalence of a disease in a population to uncover the causes of a disease, secondly the emergence of the neuroscience to understand the complexity and diversity of CP and thirdly to recognised that CP is a developmental disability with the emphasis on functional considerations (Pellegrino & Dormans 1998:6). Today, researchers recognise CP as one of the most common neurological dysfunction that occur in the developing foetal or infant brain and cause activity limitations and participation restrictions due to disorders of motor function, movement disorders and posture (Krägeloh-Mann & Cans 2009:537; Pellegrino 2012:49; Rosenbaum 2003:970). Cerebral palsy is the sensory and neuromuscular deficit caused by a non-progressive brain defect or lesion occurring during the prenatal, intra-partum, perinatal, or early postnatal periods (Barlett & Palisano 2002:237). Hoon and Tolley (2013:424), describe CP as a group of chronic childhood motor impairment disorders defined by specific functional characteristics with variability in motor function with accompanied non-motor function in sensation, cognition, communication and behaviour. The performance of a child with CP and the ability to process sensory information is often compromised due to a number of factors such as disordered muscle tone and stereotyped movement patterns as state by Murchland, Lane and Ziviani (2008:341).

Rosenbaum, Paneth, Leviton, Goldstein and Bax (2007:8), compile the following definition and classification of CP. Rosenbaum *et al.* (2007:8) state "*Cerebral palsy describes a group of permanent disorders of the development of movement and posture, causing activity limitation that are attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of CP are often accompanied by disturbances of sensation, perception, cognition, communication, and behaviour, by epilepsy, and by secondary musculoskeletal problems*". An overview of children with CP who receive occupational therapy services on a regular basis was provided. Knowledge about this medical condition is important for developing appropriate intervention (Arndt, Chandler, Sweeney, Sharkey & McElroy 2008:12).

The revised International Classification of Functioning, Disability and Health (ICF) of the World Health Organization (WHO) (WHO 2001) has changed the focus of intervention. Prior to this revision, the focus was on reducing the child's impairments that interfered with function. The ICF no longer represents a hierarchy of functional levels, but rather an interaction of body functions and structures, activities and participation, which are influenced by the health of the child as well as environmental and personal factors (Eliasson & Burtner 2008:1). In the clinical setting it has been observed by the researcher that the environment may influence a child's activities and participation as readily as body structure and function. For children with CP, the ICF can be a good framework in the formulation of problems from the different domains and assist to plan intervention leading to specific functional goals (Beckung & Hagberg 2002:315). Perhaps the International Classification of Functioning, Disability of Health-Children and Youth version (ICF-CY) (WHO 2007) has the greatest influence on this study. The ICF-CY stresses the assessment on visual functioning in everyday activities and tasks rather than the measurement of a few visual functions such as visual acuity and visual fields (Hyvärinen 2010:265). Careful observation, recording and analysis by the occupational therapist lead to an understanding of the child's visual functioning. Hyvärinen (2010:275) states that observations are collected from each person who is in contact with the child's functioning. International health experts have expressed their concerns about the limitations of the World Health Organisation (WHO) definition of health and have proposed the formulation of health as the ability to adapt and to self manage (Huber, Knottnerus, Green, van der Host, Jadac, Kromhout, Leonard, Lorig, Loureiro, van der Meer, Schnabel, Smith, van Weel & Smid 2011:d4163). The occupational therapist may participate in various service delivery models with in-direct or direct, individual child-centred services to provide opportunities for participation (Myers, Stephens & Tauber 2010:684; Youngstrom 2002:607).

Over the years the researcher has been exposed to many theoretical models of motor behaviour that provides a framework for understanding the phenomenon of motor changes as the child develops and which serve as a foundation for treatment approaches to central nervous dysfunction (Eliasson & Burtner 2008:2; Mathiowetz & Haugen 1994:733). From the dynamic systems theory it have been learned that the development of motor behaviour emerges as a function of many subsystems within a

task context (Smith & Thelen 2003:343). Emerging motor behaviours in infants are the result of many interactions of subsystems and the constraints of the tasks in real time (Eliasson & Burtner 2008:2; Ohgi, Morita, Khee Loo, Mizuike 2008:1023). The action perception theory proposes that movements are organised as actions in response to an infant's motivation, defined by a goal and guided by perception and planning (Von Hofsten 2004:266). The neuronal group selection theory proposes that the brain is dynamically organised into variable neuronal networks whose structure and function are selected by development and behaviour (Hadders-Algra 2010:1824). The emphasis on the interaction between the developing central nervous system (CNS) and the environment is clear in the developmental theory, considering the maturation of the CNS as only one factor that contributes to the development and coordination of complex movements that are required for active exploration in the environment (Eliasson & Burtner 2010:3). From the Bobath/Neuro-Developmental treatment (NDT) concept, it has learned and still practise, the neurophysiologic requirements for efficient co-ordination, i.e., typical tone, all degrees of reciprocal innervations, and the availability of all patterns of movement explained by using current knowledge, viewed in the very important context of cognition, sensory and perceptual ability for participation (Bobath & Bobath 1985:2; Mayston 2005:10). Motor learning had been defined as a set of processes associated with practice or experience leading to relatively permanent changes in the capability for movement (Carr & Shepherd 1996:72, Kantak, Sullivan & Burtner 2008:261). Sensory integration continues to serve as an important clinical frame of reference for the occupational therapist (OT) in the assessment and treatment of people who have functional disorders in sensory processing (Parham & Mailloux 2010:325). Treatment approaches and frameworks for the improvement of function in children with CP are numerous and based on different assumptions about the maturation of the damaged nervous system and its adaptive capacity (Mathiowetz & Haugen 1994:733; Dodd, Imms & Taylor 2010:42).

The researcher acknowledged the complex interaction of systems and higher level processes involved for optimal movement during participation in this context. The researcher is also aware that these systems and higher level processes can cause an enormous range of problems in a child with brain damage (Smith & Thelen 2003:347). Clinicians are increasingly aware of the importance of characterising children in terms of their functional abilities and task completion influenced by the

environment (Preissner 2010:728). The ability to reach, eat, grasp, and hold a conversation includes action that allows us to actively explore and interact with the environment for which we need postural control (Levin & Sveistrup 2008:109). Charles (2008:147) states that no functional movement exists in isolation but is rather embedded in complex situations and nested into a given postural setting that enables a child to move the eyes, head and upper- extremity during a reach sequentially or in conjunction depending on the constraints of the task.

Most children with CP carry out of their functional activities, such as eating, drawing and playing while sitting, but often have difficulty with postural control (Levin & Sveistrup 2008:110). According to Shumway-Cook and Woollacott (2001:221), the emergence of postural control can be characterised by both the presence of limited innate components of reactive control and the subsequent development of more refined rules that relate sensory inputs reporting the body's position with respect to the environment, to motor actions that control the body's position.

Hadders-Algra, Brogren and Forssberg (1998:501) state that the control of posture is a complex task, because the nervous system has to deal with a multi-segmented body having many degrees of freedom. Postural control, according to Shumway-Cook and Woollacott (2001:164), is the ability to maintain an appropriate relationship between the body segments and between the body and the environment for purposes of a task. Shumway-Cook & Woollacott (2012:248) further state that the term posture is often used to describe both biomechanical alignment of the body as well as the orientation of the body to the environment. Postural alignment influences how muscles are recruited and coordinated for recovery of stability therefore changes in body alignment influence many aspects of postural control (Shumway-Cook & Woollacott 2012:191).

Dysfunctional postural control is one of the key problems in children with CP which interferes with the activities of daily life (De Graaf-Peters, Blauw-Hospers, Dirks, Bakker, Bos & Hadders-Algra 2007:1192). Stability in sitting is assured by the development of co-activation of the direction specific neck and trunk musculature (Levin & Sveistrup 2010:109). Postural muscle activation precedes, accompanies and follows an intended action or task and emphasises the interrelatedness of client and

environment and is heavily dependent on previous experience and learning (Msall & Park 2008:800, Preissner 2010:734; Shumway-Cook & Woollacott 2012:263).

The reciprocal interactions between eye movements and posture in children with CP are emphasised by Soul and Matsuba (2010:47). Levin and Sveistrup (2008:112) reiterate the importance to use specialised seating in the child with CP to optimise body alignment so that the child can make use of the most effective movement patterns of the arm and the hand.

It is important to understand the contribution of a number of systems and how they interact with each other. Children rely on vision and the processing of visual information for almost all interactions with the environment (O'Brien & Williams 2010:257). Newly sitting infants rely heavily on visual inputs when controlling the sway and this dependence decreases with increasing experience in sitting (Shumway-Cook & Woollacott 2012:205). The muscle activation of children with CP is slow in amplitude; there is a disruption of the normal sequencing of muscle activation patterns in the postural alignment, with weakness, reduced range of motion and changes to the structure and function of skeletal muscles (Shumway-Cook & Woollacott 2012:270; Hedberg, Carlberg, Forssberg & Hadders-Algra 2005:312). This phenomenon is reflected in the eyes of a child with CP, as observed by the researcher. Similarly, O'Brien and Williams (2010:258) report that eye movements may serve as an early biological marker of motor control problems. In other words the visual process is very much a part of our motor or movement system and acts to support our balance, posture and movement (Padula 2003:1).

The vision and postural control demands differ from task to task. In some cases of children with neurological motor disturbances a serious visual defect may be the leading and presenting symptom, particularly if the neuromuscular defect is mild. In others the visual defect may be overlooked because of the severity of the neuromuscular disability. The combinations of visual and neuromuscular disabilities reduce the child's functional goal-directed tasks (Baker-Nobles 2011:16).

Visual impairment, an accompanied disturbance in children with CP, can include peripheral problems, such as ocular disorders, central problems covering the spectrum of cerebral visual impairment and oculomotor dysfunction as well as visual-cognitive dysfunction (Geddie, Bina & Miller 2013:176; Ghasia, Brunstrom,

Gordon & Tychen 2008:572; Erhardt 1990:1; Fazzi, Signorini & Bianchi 2010:203; Scheiman 1997:295).

As a result of this variability in presentation of CP and with different accompanied disorders the focus and role of the OT vary widely for different individuals. Occupational therapists must therefore consider how the visual system might affect performance (Russel & Nagaishi 2010:744).

While the clinical theories and practices may be soundly reasoned, it appears that minimal investigation has been done into the association of eye movements with the postural alignment of children with CP.

Reading, writing, walking, having social interactions or playing ball with a friend are important functional skills that are dependent on normal visual functioning (Sheiman 1997:1). Warren (1990:391) states the importance of oculomotor functions whereby the central nervous system obtains visual information from the environment to be independent and free from body and head. Warren (1990:391) expresses the concern that there appears to be little systematic considerations of a patient's visual profile in occupational therapy and suggests further research to define the extent of this influence and to develop habilitation principles. The relevant visual skills chosen for this study are limited to binocular fixation, saccadic movements, ocular pursuit, gaze shifting, peripheral awareness and pupillary response. This should not construe to indicate that other visual skills are less important, but rather the chosen ones were deemed to be those constituting the greatest number of clinical encounters for children with CP (Erhardt 1990:125). The eye movements were applicable to the demands for function. Ideally both eye movements and visual acuity need to be assessed in conjunction with postural alignment, but the necessary special testing material for visual acuity that can be used by occupational therapists (OTs), is expensive and was not available at the time of the study in South-Africa. In addition to this, the lack of postgraduate courses in the field of visual impairment, for the development of theoretical and practical knowledge coupled with practical experience gained in the clinical setting with the rest of the medical team (the ophthalmologist and optometrist) was another hindrance (Stolk, Arentz & Sterkenburg 2009:17; Mokoko & König 2011:3). As the special testing materials for *visual acuity* (Teller acuity cards and/or Cardiff acuity test), were not available at the

time of the study a different unique approach for this study was used. Instead of looking purely at 'laboratory based' techniques, a practical or 'field' knowledge was used to determine if there was any association between eye movements and postural alignment in children with CP especially in the rural areas. Stolk *et al.* (2009:17) acknowledge this lacuna by stating that information of the visual functioning is not always available due to lack of special tests needed to assess a child with CP's functional vision, since such a child is not able to speak or point out what he/she is able to see. Roman-Lantzy (2007:2/30) follows a pragmatic approach by stating that if it is not possible to have a visual assessment done, you have to learn to recognise which signs might indicate visual impairment that will interfere with function. This was the approach followed by the researcher in view of the lack of established research in this instance.

1.2 PROBLEM STATEMENT

Cerebral palsy is a potentially complex condition. The primary motor disorder of CP is described in terms of the nature of the movement and the resultant level of motor function which include the presence of abnormal muscle tone and specific movement disorder. According to Rosenbaum *et al.* (2007:10) one of the core features of CP are abnormal gross and fine motor functioning and organisation that can lead to difficulties in walking, feeding and swallowing, coordinated eye movements, articulation of speech, and secondary problems with behaviour, musculoskeletal function and participation in society. In addition to the disorder of movement and posture, people with CP often show other accompanied neuro-developmental disorders or impairments such as sensation specific visual impairments and defects (Dutton 2008:13). Vision may be affected both as a result of the primary disturbance(s) to which CP is attributed and as secondary consequences of activity limitations that restrict learning (Rosenbaum *et al.* 2007:10). The development of occupational performances is influenced by many systems and variables. The motor and visual behaviours observed will provide insight into how and why the child with CP has difficulty taking part in activities with friends and family and learning to become part of society. The interplay between vision and motor disturbances in CP is observed in the clinical setting.

The researcher has observed in the clinical setting that children with CP have difficulty controlling their eye movements, which may be the cause of misalignment in posture, and making it difficult to actively participate in activities. The opposite can be stated, i.e. that abnormal postural tone and a misaligned posture may influence a child's ability to make use of their eye movements for processing during a task such as localising a person in a room, having an accurate reach to grasp a toy, or maintaining focus during a conversation. The researcher is interested not only in whether the child with CP is able to see but also in how the child uses the movement of the eyes in relation to postural alignment.

This all led to the question whether there is any association between eye movements and postural alignment in children with CP for which one needs a detailed description of the disability profile with respect to eye movements and postural alignment in children with CP in sitting at rest. According to the researcher's knowledge there is limited available research to indicate a possible association between eye movements and postural alignment in children with CP.

The aims and objectives of this study were the following:

1.2.1 AIM

The aim of the study was to describe eye movements and postural alignment and to investigate if there was a possible association between eye movements and postural alignment in sitting in the frontal plane of children with CP between the age of two and ten years.

1.2.2 OBJECTIVES

- To describe the eye movements of children with CP.
- To describe the postural alignment of children with CP in sitting in the frontal plane.
- To establish whether an association exists between eye movements and postural alignment during sitting in the frontal plane of children with CP.

1.3 METHODOLOGY

A non-experimental, quantitative approach was followed. A quantitative approach is used to quantify the variation of eye movements and postural alignment of children with CP. Information was gathered using quantitative variables namely postural alignment of sitting in the frontal plane and eye movement of children with CP (Fouché, Delport & De Vos 2011:155).

A descriptive study was used to describe the eye movements and alignment in body segments over the base of support against gravity (Fouché & Delport 2011:61).

A correlation study was used to investigate the possible association between postural alignment and eye movements in children with CP (Fouche & De Vos 2011:96). The data was gathered by using structured observed eye movements and postural alignment in children with CP to determine whether and to what degree a association exists between these two quantifiable variables (Leedy & Ormrod 2010:108, Fouché & De Vos 2011:96).

Before conducting the study all interviews and structured observations were pilot tested at three sites, with the necessary consent. The same sites were used for the main study with the necessary consent. Non-probability sampling specific, convenience sampling (cf. 3.3.1) was used for this study (Strydom 2005:57; Strydom 2011a:231). Fifty seven children with CP, between two and ten years of age participated in the study after meeting the pre-determined inclusion criteria.

The data was collected by means of structured interviews and structured observation schedules relevant to the two main characteristics, postural alignment and eye movements for children with CP. The data collected was in the form of numbers reflecting specific measurements of the characteristics in questions (Leedy & Ormrod 2010:184).

The researcher's preplanned and prestructured data was coded in ordinal Likert scale numbers that allowed the researcher to use descriptive statistics, two-way frequency tables and non-parametric Spearman rank order correlation coefficients to determine whether an association exists between eye movements and postural alignment in children with CP (Ellis & Steyn 2003:51; Fouché & Bartley 2011:273).

1.4 THE VALUE AND EXTENT OF THE STUDY

This study aimed to create a contribution to the body of knowledge of occupational therapy. Such knowledge could be most suitable for OTs working in the paediatric occupational therapy field, with special interest in children with CP, with the outcome of occupational therapy intervention to support participation in the context in which the child function on a daily basis. Confirmation of a possible association between eye movements and postural alignment could result in further studies for developing measurement tools and appropriate effective interventions to enhance performance of children with CP.

1.5 ETHICAL CONSIDERATIONS

Ethical approval was obtained from the Ethics Committee (ECUFS no. 20/40) of the Faculty of Health Sciences, University of the Free State before commencing of the study. Guidelines for ethical and responsible conduct were followed during the planning and execution of this study (Leedy & Ormrod 2010:101). The study was performed before the act of assent came into effect. The informed consent form was accompanied by an information letter about the study in English and Tswana according to their preference (cf. Appendix A). An interpreter proficient in the applicable African language was available throughout the study. The study was free, voluntary and that they were allowed to withdraw from the study at any stage should they wish to do so.

All information was handled confidentially. Parents or guardians were informed that the data could be used in future publications. The participants and centres were not put at risk and all equipment used in this study was not hazardous. The research will be submitted for possible publications in accredited journals.

1.6 CHAPTER EXPLANATION AND OUTLINE

Chapter 1: *The introduction and orientation of the study*: Provides an overview of the study leading to the problem statement, aims and objectives of this study. A summary of methodology is included with the emphasis on the value of this study for OTs in future. The importance of the ethical considerations is highlighted.

Chapter 2: Contains a *literature review* of the following constructs relevant to this research study:

- Review of the literature on CP
- Overview of postural alignment
- Model of visual efficiency in skill-specific eye movements

Chapter 3: *Research Approach and Methodology*: The research methodology is described in detail and includes ethical clearance and implementation obtained for the study, a description of the research design, study population, sampling, pilot study, measurement instruments and methods used for collecting the data and data analysis.

Chapter 4: *Results*: This chapter presents the results of this study. Results are displayed and discussed in graphs and tables on the analysis of the data. Findings are discussed according to the categories emerging from the data. This chapter forms the basis on which any discussion, conclusions and recommendations are made.

Chapter 5: *Discussion of results*: This chapter discusses and interprets the results, and concludes the results in relation to the research aim and objectives. The results obtained are further described and summarised in this chapter.

Chapter 6: *Conclusions and Recommendations*: The researcher discusses the main findings and relates the results obtained to the literature. This chapter consists of conclusions, summary of contributions, the limitations of the study and recommendations for future research.

1.7 SUMMARY

This chapter presented a brief account of the clinical reasoning and the background to the study. In the next chapter, a literature review will highlight the importance of this study. A theoretical framework and different studies will be discussed and argued, with definitions and terminology to support the research.

CHAPTER 2

LITERATURE STUDY

2.1 INTRODUCTION

In the previous chapter an introduction and orientation of this study was given, which included the problem statement, aim of the study, methodology, the value of the study, ethical considerations, and the outline of the chapters. This chapter describes and explains the theories and research that underpin this study. This chapter will attempt to give an overview of the main issues underlying the research, namely eye movements and postural alignment in sitting amongst children with CP. This information will enable an OT to understand the impairments constraining body functions and structures and limitations to activities that act as a barrier to the child's participation in childhood occupations in a specific context.

From what the researcher has learned over the years in the clinical setting as an OT phrases such as 'Sit up straight' or 'Look at me' served no purpose. Posture is more than a straight back and looking is more than just seeing. Clinical treatment of the child with CP requires both knowledge and skill (Schleichkorn 1999:7). Part of an essential knowledge base in treating children with CP is the understanding of postural alignment and eye movements. A unique approach based on observed – clinical reasoning was used by the researcher in practice to describe eye movements and postural alignment and to investigate whether a possible relationship existed between eye movements and postural alignment in sitting (Smith Roley & Schaaf 2006:18).

There are many concepts, assumptions, expectations, beliefs and theories that support and contribute to a conceptual framework in the treatment of children with disabilities. The aim of this study was not to identify the best framework across all forms for practice but rather to use it as a travel map to explain the route taken by the researcher to complete this study. There may be paths that have never been explored, while other OTs or researchers might have tried a similar path with a different outcome. Based on clinical experience and knowledge of others the following frameworks, beliefs and theories explained the map used by the researcher to reach

the destination for this study. The researcher identified motor and visual functional problems through observation, while treatment strategies based on current scientific knowledge are devised to address these impairments (Preissner 2010:728; Case-Smith 2010a:3).

2.2 WORLD HEALTH ORGANISATION

The vast majority of children with developmental disabilities can expect to survive to adulthood due to medical technology and improvements in service delivery of acute health care (Dosa, White & Schuyler 2013:697). The International Classification of Functioning, Disability, and Health (ICF) is a framework, proposed by the World Health Organisation (WHO) to understand the impact of the social and physical environment on health and health-related states for individuals with developmental disabilities (Simeonsson, Leonardi, Lollars, Bjorck-Akesson & Hollenweger 2003:602). The ICF provides a standard language to describe the manner in which people with a health condition function in their daily lives, recognising the social and physical environment and serving as a useful framework for structuring intervention services for children with disabilities (Imms, Dodd & Taylor 2010:3; Shumway-Cook & Woollacott 2012:147; Simeonsson *et al.* 2003:602).

The ICF conceptualises disability as having a medical or health condition as one of its core components, together with one or more related impairments (Kerr, McDonough & McDowell 2006:22). The health condition can be expressed at three different but equally important levels. Firstly, the body functions are defined as the physiological functions of body systems, while body structures refer to the anatomical construct of the body (impairment); secondly, activity is defined as the execution of tasks by, or actions of, an individual (activity limitations); and thirdly, participation refers to involvement in life situations (participation restrictions) (Case-Smith, Law, Missiuna, Pollock & Stewart 2010:28; Richardson 2010:217). Therefore the ICF no longer represents a hierarchy of functional levels, but rather a dynamic interaction between these three levels and the context of the individual, which includes personal and environmental factors (Simeonsson *et al.* 2003:604; Rosenbaum & Gorter 2011:3). Eliasson and Burtner (2008:1) state that all the levels in the ICF are interconnected without any hierarchy of implied importance; therefore within these dynamic systems, changes in any area of the framework may potentially

have influenced elsewhere in the system. An extension of the ICF, the International Classification of Functioning, Disability and Health for Children and Youth (ICF-CY) has been developed to address the unique concerns of developing children (Case-Smith *et al.* 2010:28; Hyvärinen 2010:265). The goal of the ICF and the ICF-CY is to develop uniform concepts and terminology in health, education and related services (Simeonsson 2009:71).

The Occupational Therapy Practice Framework (OTPF) acknowledges the strong connections between its practice framework and the ICF, with an individual's performance and participation being inextricably linked to the context, activity demands, and client factors (Case-Smith *et al.* 2010:28; Creek 2010:27; Youngstrom 2002:608). This will enable the OT to determine the child's functional performances or occupation profile in a specific context and to work with the family to identify the most appropriate goals (Stewart 2010:194).

Rosenbaum and Gorter (2011:1), formulate a new set of ideas grounded in the ICF into a series known as 'F-words' in child neurodisability, namely function, family, fitness, fun and friends, thus opening up possibilities for thought and action that should benefit children, families and professionals. The ICF therefore provides a framework to assist the researcher in the clinical reasoning process and has resulted in a more overt appreciation of the complex interactions between a person, their environment and activities in the presence of a health condition (Huber *et al.* 2011:343).

Children with CP are known to have visual disorders and there is strong evidence that such visual disorders are not merely associated problems, but rather on par with the motor disorders (Fazzi *et al.* 2010:194). The ICF-CY stresses the assessment of visual functioning rather than the measurement of a few visual functions such as visual acuity and visual fields (Hyvärinen 2010:265). The WHO publication 'Managing of Low Vision in Children and the ICF-CY' provides a practical framework to assess and to report functional vision, which includes eye movements, using four domains where functional vision is reported for – communication, orientation and mobility, sustained visual tasks and activities of daily living that are present in all cultures and at all ages (Buultjens, Hyvärinen, Waltheres & Dutton 2010:228; Hyvärinen 2004:1/4).

2.2.1. FUNCTIONAL VISION

Several specialists may be involved in the assessment of a child's visual functioning, including the ophthalmologist and optometrist, to determine causation and degree of visual dysfunction, and the results need to be explained to the parents in a clear, understandable way with accompanying reports for the OT (Buultjens *et al.* 2010:228). Buultjens *et al.* (2010:228) state that: *"This information needs to be used to guide reassessment of functional vision in the familiar and non-threatening environment to ensure that the habilitational strategies applied, match the child's visual abilities"*.

Functional vision is a critical component to understand the extent of the visual status of a child with CP and the way in which the child functions in essential activities of daily life. It has been documented by Trief and Shaw (2009:26) that no universal protocol exists for functional vision assessment. The child's posture, environment, appropriate physical presentation of objects and toys in relation to the child's visual field and deliberate contrast of materials and color selection are particular important when documented near and distance vision (visual acuity), visual field and ocular motility during everyday activities (Trief and Shaw 2009:27). Motility is divided into binocular fixation stability, saccadic and pursuit functions (Scheiman 1997:85).

The ICF recognises that improvement may be achieved through manipulation of the child's environment and therapy requiring a change in the child's body, therefore the classification is in agreement with the social model of disability (Colver 2007:16). The ICF provides a useful framework for planning intervention strategies and for evaluating outcomes. Tools measuring therapy intervention and service delivery can be similarly organised (Saloojee 2006:21).

Occupational therapists have the opportunity to observe each child with CP in different situations and can relate visual performances to age-related norms (Hyvärinen 2010:265). The impact of both the neuro-muscular and visual disabilities becomes apparent as the child grows older and may impact on sustained vision related tasks, mobility, orientation, communication, interaction and activities of daily living (Buultjens *et al.* 2010:228).

2.3 CEREBRAL PALSY

Cerebral palsy can be described as a group of chronic childhood motor impairment disorders defined by specific functional characteristics that are non-progressive but ever-changing, rather than by the underlying causes (Hoon & Tolley 2013:424; Krägeloh-Mann & Cans 2009:537; Sanger Delgado, Gaebler-Spira, Hallett & Mink 2003:e91). It is a well recognised neurodevelopmental condition beginning in early childhood characterised by impaired control of movement and posture, signs of neurological dysfunction and persists through the lifespan (Hoon & Tolley 2013:425; Rosenbaum 2003:970; Rosenbaum *et al.* 2007:8; Fairhurst 2012:122).

The majority of children with CP do not have musculoskeletal deformities at birth. Instead, these develop with time to the combined effects of the movement disorders and impaired gross motor function (Graham 2007:21; Rogers 2010:160). Children with CP present multiple impairments, including muscle weakness that has been associated to limitations in motor activity performances, spasticity and deficits in coordination (Dos Santos, Da Costa, Golineleo & Rocha 2013:1). The incidence of musculoskeletal deformities in CP, according to Graham (2007:22) is very high and includes dynamic or myostatic contractures, torsional deformities and joint instabilities, such as in the subtalar and midtarsal joints, with the most common and clinically important joint instability in children with CP being hip displacement (incidence to be 35%). A study on musculoskeletal pain in adults with cerebral palsy compared with the general population found that CP is associated with musculoskeletal deformities, such as subluxation and dislocation of the hip, abnormalities of the foot, patella alta, scoliosis, pelvic obliquity and contractures (Jahnsen, Villien, Aamodt, Stanghelle & Holm 2004:82).

Hoon and Tolley (2013:435) report that approximately 40% of children with CP develop epilepsy. Pellegrino (1998:86) states that there is a high incidence of seizures and seizure disorders among children with CP therefore, it is important to recognise and characterise these correctly and obtain adequate seizure control while minimising the side effects of the medication. According to Soul and Matshuba (2010:26) visual attention and visual acuity are markedly impaired when seizures are uncontrolled. Mercuri, Guzzetta, Ricci and Cioni (2010:75) find that in the case of term infants with encephalopathy, the presence of epilepsy in the first two years is

always associated with an abnormal visual outcome, irrespective of the extent of the brain lesion but also mention, that spontaneous resolution of the visual defects may occur. This is probably a result of the considerable powers of healing and regeneration (plasticity) in the developing brain.

Hearing loss in children with CP range from 3% to 10% but due to the difficulty on identifying hearing problems, particular with unilateral or high-frequency hearing loss the incidence is probably higher (Dormans & Pelligrino 1998:25).

2.3.1 EPIDEMIOLOGY AND RISK FACTORS

There is some concern that the severity of disability may be increasing among children with CP, making continued monitoring of the characteristics of such children necessary (Cans 2000:816). In the eight countries that participated in the 'Surveillance of CP in Europe' (SCPE), the prevalence rate for CP occurs in two to three live births out of every 1 000 (Cans 2000:816). According to the researcher's knowledge there is no register in Africa to determine the prevalence rate for CP.

Krägeloh-Mann and Cans (2009:537) state that in more than 80% of cases, CP is caused by brain lesions or mal-developments that can be attributed to different timing periods of the developing brain. Cerebral palsy prevalence increases with lower birth weight and higher immaturity (Krägeloh-Mann & Cans 2009:542). The increased risk of CP in premature infants is related to complex interrelations between destructive and developmental mechanisms, with periventricular leucomalacia (PVL), intraventricular haemorrhage and intraventricular hemorrhage and hypoxic-ischemic encephalopathy being most common in premature infants (Koman, Smith & Shilt 2004:1620). Both indirect and direct infections of the foetus and/or newborn infant have been shown to be associated with CP, as has bacterial meningitis (Hoon & Tolley 2013:426). The power of neuro-imaging in revealing the cause of CP is well accepted and can define different kinds of brain pathology, including various congenital malformations and different destructive lesions in white and grey matter (Flodmark 2007:18). It is often impossible to find a cause in the history of children with clear clinical evidence of CP (Rosenbaum 2003:970).

2.3.2 DEFINITION OF CEREBRAL PALSY

The definition and classification of CP has been a source of great confusion and controversy ever since the concept was introduced and has been debated for more than 150 years. Discussions about how the different manifestations of CP can best be classified continue to the present day (Dormans & Pellegrino 1998:5; Morris 2007:3). Abnormal, unwanted and excess movements are frequently seen in children with neurological disorders and are an important clinical finding with significant implications for diagnosis and treatment. However, the lack of agreement on standard terminology and definitions interferes with clinical treatment and research (Sanger *et al.* 2003:e90).

The definition for CP used for this study was compiled by an international multidisciplinary group, clarifying the CP concepts and recognising that the key motor deficit is often accompanied by other neurodevelopmental impairments (Rosenbaum *et al.* 2007: 9):

“Cerebral palsy describes a group of permanent disorders of the development of movement and posture, causing activity limitation that is attributed to non-progressive disturbances that occurred in the developing fetal or infant brain. The motor disorders of CP are often accompanied by disturbances of sensation, perception, cognition, communication, and behaviour, by epilepsy, and by secondary musculoskeletal problems”.

This definition covers a wide range of clinical presentations and contains the variables that are relevant to this study (Rosenbaum *et al.* 2007:9).

“Movement and posture” in terms of the definition refers to abnormal gross and fine motor functioning and organisation that reflects atypical postural control as the core feature of CP.

“Sensation” in terms of the definition is vision, hearing and other sensory modalities that may be affected both as a primary disturbance to which CP is attributed and as a secondary consequence of activity limitations, restricting learning and the perceptual development experience.

2.3.3 CLASSIFICATION

Cerebral palsy is clinically diagnosed on the basis of the presence of delays in motor development and distinct abnormalities of the neurological examination (Damiano 2007:16). The condition presents when children have not mastered their milestones and when they show qualitative differences in motor development such as asymmetric gross motor function or unusual muscle stiffness or floppiness in the first 12 to 18 months, unless it is mild (Rosenbaum 2003:970). It is generally agreed that the child should be at least three years of age before the CP diagnosis is established, as the typical neurological signs take time to develop (Krägeloh-Mann & Staudt 2010:65). However, according to Rogers (2010:156) and Sanger *et al.* (2003:e89) the term CP is often used when an injury occurs in children before two years of age, and an early diagnosis of CP is important to elicit early intervention services in order to optimise the child's potential for development and to prevent secondary disabilities.

The information available to provide an adequate classification of the features of CP in any individual will vary over the age span, due to changes over time and across geographic regions and settings (Rosenbaum *et al.* 2007: 11). Certain characteristics or combinations of characteristics may be more useful than others, depending on the purpose of classification (Rosenbaum *et al.* 2007:12).

Individuals with CP have traditionally been grouped by the predominant type of motor disorder, and therefore the predominant features determine classification (Krägeloh-Mann & Cans 2009:538). This grouping has been adopted by the classification system described in the SCPE reference and training manual, which divides CP into three groups based on the predominant neuromotor abnormality – i.e. spastic, dyskinetic or ataxia – with dyskinesia further differentiated into dystonia and choreoathetosis (Cans 2000:821; Dammann & Kuban 2007:17; Krägeloh-Mann & Cans 2009:538). The extent and topography determine the clinical subtype of CP and are also related to the presence and severity of associated disabilities (Krägeloh-Mann & Cans 2009:538). However, it can be argued that many children with CP have mixed presentations where no predominant type – or more than one type – of tone and movement abnormalities is present (Imms & Dodd 2010:10). The dominant features should determine subtype classification (Cans, Dolk, Platt, Colver, Prasauskiene & Krägeloh-Mann 2007:35).

Rosenbaum *et al.* (2007:11) state that assigning individuals with a CP diagnosis to a distinct clinical group is not a straightforward matter and will depend on the characteristic(s) chosen as the basis for classification. No single approach has emerged as definite, since all depends on the purpose of the classification.

There has been significant progress in classifying the movements and manual abilities associated with CP, as these are probably easier to observe and categorise. The gross motor functional classification system (GMFCS) has been widely adopted as a means to classify movement abilities (Imms & Dodd 2010:10; Rosenbaum *et al.* 2007:12). The GMFCS classifies a person's ability to self-initiate movements related to sitting, transfers and walking, while typical performance rather than maximal performance is rated using a five-level scale (Palisano, Rosenbaum, Barlett & Livingston 2007). Distinctions are based on functional limitations, the need for hand-held mobility devices (such as walkers, crutches or canes) or wheeled mobility, and to a much lesser extent, quality of movement. The distinctions between levels I and II are not as pronounced as the distinctions between the other levels, particularly for infants less than two years of age. Although the GMFCS has since been widely adopted, it was not in common use at the time of this study and was therefore not used for this purpose.

2.3.4 PATHOPHYSIOLOGY OF CEREBRAL PALSY

Pathophysiology within the action system includes the *motor cortex* causing spasticity and abnormal synergies of movement, subcortical structures such as the *cerebellum* that produces unstable movements and tremors as characteristics of the ataxia child, and *basal ganglia* resulting in a wide range of impairments affecting the control of movement, including motor weakness, fluctuating muscle tone and coordination problems, as well as abnormal synergies of movement described as dystonia or athetosis (Rogers 2010:156; Shumway-Cook & Woollacott 2012:140).

CP children with spasticity often suffer from a number of impairments including muscle weakness. Muscle weakness in CP occurs primarily as a result of a nonprogressive lesion of the brain which impairs cortical innervations of descending pathways resulting in secondary adaptation in the muscle (Damiano, Quilivan, Owen, Shaffrey & Abel 2001:40). These secondary adaptations which could contribute to weakness in CP include smaller muscle size, reduced agonist muscle activation

and/or changes in patterns of coactivation (Hussain, Onambele, Williams, & Morse 2013:2/26).

Pathology in the central nervous system (CNS) impairs the coordination of posture and movement due to disordered muscle tone that results in stereotyped movement patterns, producing atypical interactions with other bodily systems, affecting the ability to process sensory information, directly or indirectly impacting on functional skills that influence the individual's participation, and causing musculoskeletal impairments that develop secondary to neuromuscular impairment and which can significantly constrain functional movement (Howle 2005:1; Mantovani 2007:26; Murchland, Lane & Ziviani 2008:341; Shumway-Cook & Woollacott 2012:140). Muscle and postural tone keep the body from collapsing in response to the pull of gravity (Edwards 1996:16, Murchland *et al.* 2008:341; Rogers 2010:156), but it must be low enough to allow selective, isolated movements (Bryanston, Boss, Brien, Mclean, McCormick & Svestrup 2006:123). Normal tone changes instantaneously, adapting to the movement requirements dictated by the task parameters (Howle 2005:17). Tone is a complex physiology amalgam of different physiological processes, affected by biomechanics, arousal and the context or conditions under which it is assessed (Capelovitch 2012:23). According to Capelovitch (2012:23) tone is the sum of the latter, interacting with the sensory systems, cognition, arousal and the environment. A 2013 study found that signs of changes in muscle properties are already present from the age of three years in children with CP and that reflex-mediated stiffness is not increased in most children with spastic CP but the main contributors for stiffness are the altered elastic properties in muscles and tendons (Willerslev-Olsen, Lorentzen, Sinkjaer & Nielsen 2013:1).

Children with visual impairment may display overall low postural tone, including instability in the shoulders and hips, while children with visual impairment whose motor experiences are limited may be fearful, which contributes to movement challenges (Russel & Nagaishi 2010:756).

Atypical muscle tone as a contributor to specific movement disorders in children with CP are well known to therapists working in this field, but the exact contribution of atypical muscle tone to functional deficits is not well understood (Shumway-Cook & Woollacott 2012:107). Observing the CP child based on the quality, quantity and

variability of motor behaviour in interaction with all other systems is a valuable indicator for clinical decision-making (Blanche, Botticelli & Hallway 1995:2).

2.4 BOBATH/NEURO-DEVELOPMENTAL TREATMENT

APPROACH

The Bobath concept, also known as neuro-developmental treatment (NDT), has influenced the researcher's way of thinking about, observing, interpreting and handling the CP child's actions, and subsequently identifying strengths and impairments, designing intervention strategies, using therapeutic actions in conjunction with other strategies in certain activities and settings, and making the necessary adjustments in terms of technique, environment or task to achieve the functional goals for participation (Bobath & Bobath 1985:2; Howle 2005:16; Mayston 2008:133).

The Bobath concept has evolved over the past 50 years and emphasises the relative importance of each system (and subsystems) that are spontaneously organised by the task parameters in the context in which the task occurs and varies with age (Howle 2005:16; Papavasiliou 2009:389).

2.5 RELATIONSHIP BETWEEN POSTURE, MOVEMENT,

STABILITY AND FUNCTION

The ability to control the body's position in space is fundamental to everything we do; it is a complex process and requires the nervous system to deal with a multi-segmented body with many degrees of freedom (Hadders-Algra, Brogren & Forsberg 1998:501). According to Bierman, Franjoine, Hazzard, Howle & Stamer (2013:18) a hallmark of human motor function is the variability of the posture and movement organisation to meet functional demands.

For purposes of this study, postural alignment was observed by asking the participant to sit on a bench with no side- and back-rest and look straight at the researcher. The task of sitting on the bench required elements of postural orientation, stability and control of the centre of mass in relation to the base of support (Shumway-Cook &

Woollacott 2012:162). Sitting without changing the base of support (quiet sitting) is a dynamic action characterised by small degrees of spontaneous postural sway dependent on postural control (Liao, Yang, Hsu, Chan & Wei 2003:624).

A quiet sitting position, rather than a standing position, was used for this study, as it offers a situation with greater stability and limits the degrees of freedom to be controlled (Levin & Sveistrup 2008:110). Liao *et al.* (2002:626) reported that CP children mostly perform their functional activities in a seated position, because the small support surface when standing imposes higher demands on their ability to control their posture. The maintenance of postural control in the seated position has not been studied in depth, but the concepts important to stance postural control are equally valid for postural control in sitting (Shumway-Cook & Woollacott 2012:193).

The ability to control one's body position in space emerges from a complex interaction of musculoskeletal and neural systems referred to as postural control (Shumway-Cook & Woollacott 2012:161). The musculoskeletal components include joint range of motion, spinal flexibility, muscle properties and biomechanical relationships among linked body segments, whereas the neuro- components include neuromuscular synergies, sensory/perceptual processes and higher-level processes for mapping sensation into action, and ensuring anticipatory and adaptive aspects of postural control (Brooks-Scott 1997:19; Copley & Kuipers 1999:18; Imms & Dodd 2010:22; Koman *et al.* 2004:9423; Rogers 2010:156).

2.6 POSTURAL CONTROL

Posture provides a frame of reference for movement and is the basis on which movements are organised and executed. Postural control is a complex skill that relies on the interactions of multiple body systems that orients a person with head vertical, eyes horizontal to the external environment (Bierman, Franjoine, Hazzard, Howle & Stamer 2013:18). As an infant gain a new posture, the infant needs to learn the critical parameters for the particular set of problems in that position and develop new strategies to cope with changing conditions and the novel features. For this reason sitting was observed without support as the demands placed on various body systems will be different comparing to supportive sitting (Bierman *et al.* 2013:19). All tasks

need postural control and involve the control of the body's position in space in order to achieve orientation and stability (Brogren, Hadders-Algra & Forssberg 1998:591; Hadders-Algra 2002:439; Shumway-Cook & Woollacott 2012:162).

Orientation can be referred to as the ability to maintain a relationship between the body segments (biomechanical alignment of the body) and between the body and the environment (orientation of the body to the environment) for a task (Shumway-Cook & Woollacott 2001:164). Postural control develops in the first year of life as a necessity for movement in a world where gravity exerts a constant pull (King-Thomas 1999:33).

One of the primary goals of human postural control is the maintenance of a vertical posture of head and trunk against the forces of gravity, as a vertical orientation of the proximal parts of the body provides an optimal condition for vision and goal-directed motility (Hadders-Algra 2010:1829; Hadders-Algra *et al.* 1998:501; Saavedra, Woollacott & Van Donkelaar 2010:13).

Postural stability can also be referred to as balance or the ability to control the centre of mass in relation to the base of support (Shumway-Cook & Woollacott 2001:190). Every task has an orientation component and a stability component that will vary with the task and the environment (O'Brien & Williams 2010:250; Woollacott & Shumway-Cook 1990:800). Many factors contribute to postural control during a quiet stance, including body alignment that minimises the effect of gravitational forces, muscle tone, postural tone and inputs from the sensory systems that provide a frame of reference for postural control (O'Brien & Williams 2010:254).

2.6.1 POSTURAL ORIENTATION FOR SITTING

Posture is an active and dynamic process that underpins movement and function and represents the overall position of the body and limbs relative to one another and their orientation in space (Jonsdottir, Fettes & Kluzik 1997:68). Posture is a prerequisite for movement, as observed during movements for an activity (Pope 1996:138). The initial posture influence the postural activity specific to the context of the task (Jonsdottir *et al.* 1997:69).

Posture is described from a biomechanical viewpoint as the non-neural aspects of tone, which via lengthening of the muscles and other tissues enable effective muscle activation during goal-directed tasks. An aligned posture is therefore dependent on the balance of the skeleton and the symmetrical alignment of body segments (Brooks-Scott 1997:21; Cupps 1999:29; Hypes 1991:9).

Biomechanical alignment allows the body to be maintained in equilibrium with the least expenditure of internal energy (Pope 1996:136; Shumway-Cook & Woollacott 2012:168). Alignment refers to the arrangement of body segments in relation to one another, as well as the position of the body in relation to gravity and the base of support (Boehme 1988:20; Hypes 1991:7). Body segments that consist of bones, joints, ligaments, tendons and muscles are naturally aligned to oppose gravity and provide stability to the body that is in contact with a support surface, or so-called base of support, during a functional goal (Cupps 1999:29; Sabari 2008:624).

Joint alignment is that position which allows the opposing joint surfaces the least resistance to movement and provides a base for synergistic muscle activity around the joint, causing the least breakdown with weight-bearing activity (Hypes 1991:3). Each segment is balanced upon the one below, and the body functions best when each segment is properly aligned. If one segment is out of alignment, the adjoining superior and inferior segments will compensate or adapt (Bly & Whiteside 1997:7).

When sitting, body parts such as the pelvis, hips, femurs and feet are aligned with the superstructures above the pelvis, including the head and trunk, to form the base of support to counteract the force of gravity (Bly & Whiteside 1997:7; Pope 1996:143).

From an anatomical viewpoint, the goal in sitting is to achieve the maximum orthopaedic symmetry between the left and right sides of the body via a neutral pelvis to avoid obliquity, rotation and posterior pelvic tilt (Alexander & Boenig 1994; Neville 2005:7). Differences in movement between the left and right sides can be observed in a frontal plane. Movements that occur in a frontal plane will produce alternating concentric and eccentric muscle activation from side to side, establishing symmetry and preventing structural changes that occur with asymmetrical postures and movement (Bly & Whiteside 1997:12).

According to Neville (2005:9) a normal upright neutral seated posture occurs when the head, trunk and extremity are maintained in relation to one another. Neville (2005:9) stated that the ideal seated position from an ergonomic perspective is the 90-90-90 position, which can be described as follows: Sitting on a flat surface, the upright symmetrical position is characterised by extension of the trunk, the pelvis in neutral, thighs slightly abducted, parallel and horizontal and the iliac crests aligned and level with the hips (90 degrees); the knees and ankles placed at ninety degrees of flexion with the feet placed on a flat surface; the head is positioned in midline and maintained in the vertical plane as it has a direct effect on posture.

Although this upright position promotes symmetry and alignment of the body segments and linkages, this anatomically aligned posture can only be sustained for short periods of time and is rarely employed in everyday life (Pope 1996:136). The more commonly used energy-conserving postures in sitting, however, can cause damage to the biomechanical system if the individual fails to register the signals to change an uncomfortable position to avoid stress on the tissues, muscles or joints (Pope 1996:137).

The ideal alignment allows the body to be maintained in equilibrium with the least expenditure of internal energy (Shumway-Cook & Woollacott 2001:164). For purposes of this study, a plumb line was used in the anterior view to serve as a point of reference coinciding with the midline of the trunk and head (Edwards 1996:24; Kendall & McCreary 1983:19).

An enormous range of problems can contribute to postural mal-alignment and can be described as a change in the position of the body with reference to gravity and the base of support (O'Brien & Williams 2010:252). Brooks-Scott (1997:116) states that an imbalance of muscle forces may lead to skeletal deformation, as seen in scoliosis. Contractures, deformities, subluxation and mal-alignment can be part of the presenting picture in children with CP (Barlett & Purdie 2005:739). Asymmetrical alignment in sitting is commonly seen in hemiplegia due to either musculoskeletal impairment or as a strategy of compensating for other impairments such as weakness in the hemiparetic side (Exner 2010:291). Muscle imbalance and weakness, stiffness in muscle tone and an uncoordinated response between muscle groups in different

planes of movement can cause the key points of head, shoulders or pelvis to deviate from the midline (Mayston 2004:149).

2.6.2 POSTURAL STABILITY IN SITTING

Stability, also referred to as balance, is the ability to control the centre of mass in relation to the base of support and is required for movement and functional activities such as reaching for toys during play and modifying posture (Hadders-Algra 2005:99; O'Brien & Williams 2010:252). The larger the base of support and the lower the centre of mass in relation to the supporting surface, the less effort is required to maintain position and stability, which is why lying provides a far greater base of support and therefore a more stable position (Edwards 1996:24; O'Brien & Williams 2010:253). This variety of postural activities leads to the development of skills by means of a predictable sequence of motor behaviours, also referred to as milestones (Case-Smith 2010b:67).

2.6.3 MOTOR MILESTONES AND EMERGING POSTURAL CONTROL FOR SITTING

For purposes of this study, the researcher used an integrative systems model based on information from the dynamic systems theory and the theory of neuronal group selection development, which emphasises that postural control development emerges from a complex interaction of musculoskeletal and neural systems, with the organisation of elements within the postural control system being determined by both the task and the environment within which the action occurs (Hadders-Algra 2000:707; Hadders-Algra 2005:101; Hadders-Algra 2010:1823; Shumway-Cook & Woollacott 2012:197; Smith & Thelen 2003:343).

The Bobath/NDT concept recognises that motor milestones are age-appropriate behaviours with definable onset arising from ongoing interactions of the neural, body and motor systems and adapting to the influence of the physical laws of the environment (Howle 2005:16). Typical developmental milestones are well documented and these form the basis of the measurement tools used in this study (Bly 1994:7, Bobath & Bobath 1985:4, Boehme 1988:17, Day 1997: 14, Prechtl 1984:2, Trief & Shaw 2009:51).

The hallmark of typical development is variability within which multiple adaptive synergies exist to combine several postural controls for specific functions (Hadders-Algra 2002:435). This variability permits flexibility for exploration of the environment, as well as rapid perceptual and cognitive learning (Case-Smith 2010b:59). The various patterns observed provide insight into how and why a child follows a certain developmental trajectory, with the understanding that neural and body systems and their subsystems develop at different rates (Case-Smith 2010b:80; Howle 2005:17). The neural maturation is seen as only one component in an interactive system model that drives motor development, with other body systems, contextual elements, energy levels, motivation, curiosity and experience with specific tasks being of equal importance (Case-Smith 2010b:80; Howle 2005:17).

Infants in general acquire the ability to sit independently during the second half-year of postnatal life (Hedberg, Carlberg, Forsberg & Hadders-Algra 2005:312). To be able to sit independently, the infant practices a variety of different motor behaviours (Foley & Greaves 2010:74; Hedberg *et al.* 2005:313). In the first trimester the infant can lift the head, rotate and take weight on the forearms, and has experienced subtle weight shifts that help to develop dynamic stability in using vision, reaching and swiping toys (Mercuri, Guzzetta & Cioni 2008:127). The second trimester is characterised by dissociation between the body sides for rolling (Boehme 1988:64). The six-month-old infant has sufficient trunk and hip control to sit erect without support, and although still using a ring for stability, at seven months the infant uses lower-extremity positional stability. At eight months the infant may use positional stability in sitting, but is no longer dependent upon it, while at nine months long periods of sitting are achieved with knee extension, and by ten months the infant can sit for long periods with the legs in line with the body (Bly 1994:192). An infant aged nine to ten months is able to move in and out of a sitting position while playing (Hedberg *et al.* 2005:312).

The emergence of sitting with control can be characterised by both the presence of innate components of reactive control, such as the neural control of postural synergies, and the subsequent development of more refined rules that relate to sensory-afferent inputs from the somatosensory, visual and vestibular systems, reporting the body's position with respect to the environment and to motor actions

that control the body's position (De Graaf-Peters, Blauw-Hospers, Dirks, Bakker, Bos & Hadders-Algra 2007:1192).

The nervous system activates muscles in specific pre-structured patterns or so-called muscle synergies (Brogren *et al.* 1998:591). Synergistic activity refers to the interaction of muscles working together when crossing a joint for an action, assisting in a movement or stabilising a movement during a functional activity, and can be modified by experience and practice (O'Brien & Williams 2010:255). The Bobath/NDT concept recognises that the establishment and elaboration of motor synergies is the foundation of typical movement (Howle 2005:16).

From a kinematic perspective, eye-hand coordination in reaching is characterised by the sequential activation of eye, head and then hand movements. Normally eye movements alone are used to locate an object in our central visual field. If the target is positioned in the peripheral fields the eyes and head are used in order to be able to reach, grasp and manipulate (Shumway-Cook & Woollacott 2012:480).

The ability to place the hand in space and support it during the execution of an action depends on the relationship between proximal and distal control mechanisms (Levin & Sveistrup 2008:109). Reach and grasp represent two distinct components that appear to be controlled by different neural mechanisms, namely the ventromedial brainstem pathway and the corticospinal track system (Exner 2010: 278).

2.6.4 IMPLICATIONS OF CEREBRAL PALSY

Children with CP who are not able to sit independently by the age of 18 months are hampered by serious dysfunction of the basic level of postural control, depending on the postural challenge of the situation (De Graaf-Peters *et al.* 2007:1195).

Depending on the extent of the brain lesion, differences will be seen for each child with CP and may result in postural deficits from alterations in descending control as well as musculoskeletal constraints (Levin & Sveistrup 2008:111). Children with CP have the ability to generate direction-specific adjustments, but they show a delayed development in the capacity to recruit direction-specific adjustments in a task with a mild postural challenge and therefore will always have difficulties in the adaptation

of direction-specific activity (De Graaf-Peters *et al.* 2007:1190; Levin & Sveistrup 2008:11; Woollacott, Shumway-Cook, Hutchinson & Ciol 2005:456).

Hadders-Algra (2000:712) and Vereijken (2010:1851) explain children with CP as starting with limited movement patterns and a nervous system with fewer options to develop variability, which can be recognised by impaired motor synergies characterised by restricted and limited movement repertoires resulting in maladaptive ineffective synergies that are unable to adapt to specific conditions demanded by the task, such as velocity, force, timing and the sequencing of muscle execution. A child with CP is unable to adequately stabilise the head in space during dynamic tasks, which may be related to abnormal patterns of trunk muscle activation (Saavedra *et al.* 2010:19). No external support in sitting was used for this study, as the presence of support alters postural activity (De Graaf-Peters *et al.* 2007:1193). Saavedra *et al.* (2010:19) found that children with CP have deficits in head stability even during quiet sitting, and that these deficits are modulated by external postural support and vision.

2.6.5 SENSORY CONTRIBUTIONS

One of the primary goals of postural control is to stabilise the head in space, and it is in the head where the sensory organs for visual and vestibular systems are embedded, making refined head control of critical importance for both orientation and balance (O'Brien & Williams 2010:252; Saavedra *et al.* 2010:13). Vision is a dynamic interactive process of motor and sensory function and is very much a part of the motor or movement system, acting to support balance, posture and movement (Padula 2003:1). Alexander, Boehme and Cupps (1993:47) and Erhardt (1990:129) state that optimal eye movements are dependent on head and postural stability, as well as free head movement that adapts to shifts in the centre of gravity as the body moves through space.

Newly sitting infants rely heavily on visual inputs when controlling the sway, and this dependence decreases with increasing experience in independent sitting as they come to rely more on somatosensory inputs (Saavedra *et al.* 2010:13). During the process of learning to sit independently, infants learn to scale or map visual sensory information to their postural activity (Padula 2003:1). Babies as young as 60 hours old are able to orient themselves toward visual stimulation and can follow a moving

object by correctly orienting the head. This indicates that such orientation movements appear to be part of a global form of postural control involving the head and the entire body (Shumway-Cook & Woollacott 2012:202). There is a rapid transformation of vision in infants between birth and three months of age, leading to the ability to give genuine smiles and eye contact at about six to eight weeks of age (Atkinson 2002:63). Blind infants show a clear delay in head control at two months of age, including a lack of normal calibration by the visual system onto the proprioceptive and vestibular systems (Fazzi *et al.* 2010:163). Evidence exists that children with CP may have vestibular hypofunction, as demonstrated during posturography, i.e. that sensory conditions in which children must rely primarily on vestibular cues cause instability and frequent falling in children with spastic CP (Saavedra *et al.* 2010:20). Saavedra *et al.* (2010:20) state that postural sway during quiet sitting in children with CP should be below the sensory threshold for semi-circular canals; but with eyes closed, input from the vestibular otoliths contributes to stability of the head during sitting. The researcher is not aware of any research explicitly examining otolith function in children with CP.

The dynamic interaction between vision and posture leads to accurate learning, which builds perception and cognitive connections that can be readily accessed when there is an environmental demand to act and respond (Benabib 2004:1; Wade & Jones 1997:620). Vision is a dynamic, interactive process of motor and sensory function and is very much a part of the motor or movement system, acting to support balance, posture and movement (Padula 2003:1).

2.7 VISUAL PROCESSING SYSTEM/ FUNCTIONAL VISION

Vision was traditionally thought of as an isolated process affecting only eyesight or the ability to see clearly. According to Padula (2003:1) and Baker-Nobles (2011:17), research has demonstrated that the visual process is not insular, but rather a dynamic and interactive processing system used primarily for the organisation of space for balance, posture, movement and learning. It is important to have specialised analysis of vision from professions such as optometry and ophthalmology, but OTs must also understand how sensory motor function is organised, as there are over 1.9 million nerve fibres exiting each eye and making up approximately seventy percent of the sensory nerve fibres in the entire body. Two thirds of the two billion impulses per

second received in the brain are related to visual processing (Beatty 1995:146; Geddie, Bina & Miller 2013:169). Scheiman (1997:7) contend that OTs must understand the complexity and importance of the visual system in light of the significant impact of visual impairment on occupational engagement and participation. Campbell (2013:599) states that OTs also treat children whose performance may be affected by differences in sensory processing. Hyvarinen (2004:6/4) suggests that professionals must consider the quality of the image that the child has, and how this image is used in the higher visual functions in order to understand the role of vision in the development and education of the child.

Visual impairment as an accompanied disturbance in children with CP can include peripheral problems such as ocular disorders, central problems covering the spectrum of cerebral visual impairment and oculomotor dysfunction, as well as visual-cognitive dysfunction (Erhardt 1990:1; Fazzi *et al.* 2010:203; Geddie, *et al.* 2013:176; Ghasia, Brunstorm, Gordon & Tychen 2008:572; Scheiman 1997:295). Fazzi *et al.* (2010:194) state that “*Visual disorders are a main symptom in the clinical picture of CP and there is currently strong evidence that they are not just associated disorders but rather on a par with motor disorders*”.

In the way the child with CP moves the eyes with his body and head or independently from body and head in all different environmental conditions and demands of daily life activities, is a window to the brain. The ability to ‘read’ them requires clinical experience and knowledge. The eyes and brain have a contract, the brain agrees to accept what the eyes send as long as the eyes agree to look where the brain directs. From this clinical point of view the optical system, pathways and eye movements will be discussed.

2.7.1 THE EYE AS AN OPTICAL SYSTEM

When a person looks at an object, light rays are reflected from that object to the eye, and as the rays pass through the optical system of the eyeball they are bent to produce an upside-down image of the object at the back of the inner eyeball, where the image is converted to electric impulses that are carried to the brain. There the image is translated so that the object is perceived in its upright position (Riordan-Eva & Hoyt 1999:246; Scheiman 1997:13; Stolk, Arentz & Sterkenburg 2008; Stolk, Arentz & Sterkenburg 2009:19).

Any deviation from or damage to any structures mentioned above will result in visual impairment caused by ocular or cerebral abnormalities or both (Aston 2004; Evenhuis 2010:215). Cataracts (dense lens), choiriditis (inflamed choroid) and retinopathy of prematurity (abnormal blood vessels growth in retina) are common disorders of the eye in children with disabilities (Geddie *et al.* 2013:176). The processing that occurs in the different brain structures is discussed in the following paragraphs.

2.7.2 VISUAL PATHWAYS

The brain is highly complex and, according to Goodale (2010:5), the different demands on vision have shaped the organisation of the visual pathways with two distinct interaction functions: ‘vision for action’ and ‘vision for perception’, depending on the excitation of the photoreceptors that are conveyed to the brain to be processed. The retina can be described as creating vision beginning with excitation of the photoreceptors by light energy.

2.7.2.1 Retina

The retina, part of the central nervous system, contains two types of photoreceptors which respond to light (Schneck 2010:374). The rods that detect dim lights contain more photosensitive visual pigment to capture more light. Cones that are concentrated in the fovea mediate colour vision and provide greater spatial and temporal resolution (Tessier-Lavigne 1991:401). When the axial length of the eye is out of alignment with the other components, refractive errors will occur; farsightedness (hyperopia), nearsightedness (myopia) and astigmatism (cornea is not uniform, result is different levels of myopia or hyperopia in different optical planes) (Stolk, Arentz & Sterkenburg 2008).

The output neurons are the ganglion cells and are heterogeneous in the kind of information they convey. Their axons form the optic nerve (Beatty 1995:408). Goodale (2010:5) explains that some ganglion cells carry information that is particularly useful for an analysis of the spatial distribution of light energy striking the retina. Other ganglion cells carry information more related to the temporal dynamics of the retinal arrays, activated from the motion of a distal stimulus; others are sensitive for wavelengths of light entering the eye leading ultimately to the

perception for colour. The fovea (the area of the retina with greatest acuity) has the greatest density of ganglion cells (Atkinson 2002:29). Goodale (2010:5) states that by the time the sensory signals leave the eye a good deal of processing has already occurred and the world is projected on the retina as visual fields.

2.7.2.2 Visual fields

The visual field is that portion of space where objects can be perceived while the individual is fixating the eyes on one particular point, usually located directly ahead (Mokoko & König 2010). The visual field is the spatial array of visual sensations available for observation (Soul & Matsuba 2010:41). The visual field is normally an oval area in front of a person. The person sees with one eye about 160 degree in the horizontal sphere and about 130 degree in the vertical sphere (Leat, Shute & Westall 1999:245). The binocular visual field of the infant shows little development between birth and seven weeks of age, but from two months onwards there is a rapid expansion of field size until 6-8 months of age and keeps increasing till 12 months of age (Moller 1997:53).

The regions of the visual field are defined with respect to the two retinas and are named with reference to the midline, the nasal hemiretina that lies medial to the fovea and the temporal hemiretina that lies lateral to the fovea (Mason & Kandel 1991:421). Information from the right side of the visual field is projected onto the nasal side of the right eye and on the temporal side of the left eye (Stolk *et al.* 2009:26). The bundles of ganglion cell axons leave each eye and form the two optic nerves while the retinotopic organisation is maintained; that is, axons from ganglion cells near each other in the retina remain near each other in the optic nerve and in this way important spatial aspects of the visual stimulus are retained in transmission to the central nervous system (Beatty1995:167). The optic nerves from each eye join at the optic chiasm where a part of the optic nerve crosses in the chiasm. The left part of the retina of each eye is connected and form the left optic tract and the right part of the retina of each eye is connected and form the right optic tract which projects to the lateral geniculate nucleus for further transmission to the occipital lobe, the pretectal areas to the midbrain and superior colliculus (Atkinson 2002:21; Beatty 1995:168).

2.7.2.3 Projections

The three projections will be discussed in the next section.

A. Retinogeniculate projection

The retinogeniculate projections are by far the most prominent visual pathway (Hyvarinen 2004:2/2). As mentioned before the two optic nerves that leave the eyes go to the optic chiasm where all fibres from the opposite nasal halves of the retina to cross and join the fibres from the temporal retina of the same side, to form the optic tracts which carry information from the opposite field of vision to the lateral geniculate nucleus (LGN).

From the lateral geniculate nucleus, neurons of the parvocellular and magnocellular remain separate, project through the optic radiation and end in the visual area one (V1) which is also known as area 17 of Brodmann, or primary visual cortex and is located in the calcarine fissure of the occipital lobe (Dutton 2008). V1 is connected to several cortical and subcortical areas (Mercuri *et al.* 2010:67).

The manner in which the retina connects with the visual cortex dictates the topographical position of a visual defect (Porro & Wittebol-Post 2010:85). In general and important for this study, retinal and optic nerve defects produce defects of the visual field of one eye; damage to the chiasmal part of the visual pathways produces defects of the temporal visual fields of both eyes, and damage to the retrochiasmal part of the visual pathways produce defects of the contralateral visual field of both eyes, as a homonymous quadrantanopia, or hemianopia (Stolk *et al.* 2008; Porro & Wittebol-Post 2010:85).

In this study, peripheral visual fields were recorded to determine each participant's 'visual field map' as seen by the participant, using a confrontation method of keeping the participant fixated on a particular target while presenting objects at various points in his/her visual field (Porro & Wittebol-Post 2010:85). In typical development, the visual field of the infant depends on the distance at which the target is presented, whether in a static or kinetic field, and how interesting the target is perceived to be. An important milestone seems to be between two and four months of age when the

infant develops the ability to switch visual attention to an object, with rapid expansion of field size between the ages of two and 12 months (Moller 1997:53).

Visual field defects can improve through training in saccadic movements, with cooperation as a prerequisite, but the results found in this regard are controversial (Porro & Wittebol-Post 2010:86). Porro & Wittebol-Post (2010:86) also find several signs of neuronal plasticity of the visual system, where visual field defects diminish with time due to functional reorganisation or rerouting of neuronal axons through non-damaged parts of the visual pathways – a phenomenon that seems to occur frequently after early brain damage.

The occipital lobes process primary visual information, serving resolution (acuity), colour and contrast perception, visual field analysis and perception of movement (Dutton, Calvert, Ibrahim, Macdonald, McCulloch, Macintyre-Beon & Spowart 2010:117).

Acuity or clarity of vision is a recordable aspect of central visual function; however, it is not a measure of functional vision, and damage to the brain can impair acuity (Dutton 2008). Visual acuity is formally defined by the finest detail (minimal angle of resolution) that is visually detectable (Good & Fulton 2010:77; Stolk *et al.* 2009:16). Environmental factors can often influence visual behaviour, and testing visual acuity in a clinic may not equate with the circumstances at home or at school, meaning that history-taking from parents, educators and other team members can be more informative than a single visual acuity estimate in a clinic setting (Colenbrander 2010:282). According to the results of a study by Saavedra *et al.* (2010:21), children with mild to moderate CP may be working harder than their peers to stabilise their vision for academics, and as most ophthalmologists evaluate and adjust prescriptions based on head-fixed testing, it may be necessary to confirm visual acuity with head-free testing to account for the contribution of postural control to acuity.

Beyond V1, visual information is conveyed to a number of striate areas for higher visual processing and can be identified by two streams, namely the ventral and the dorsal stream (Atkinson 2002:32). The ventral stream pathway projects to the inferotemporal cortex and is responsible for visual recognition and route finding, whereas the dorsal stream projects to the posterior parietal cortex and is responsible

for analysing the complexity of the visual scene and guiding body and eye movements, thus contributing to attention for visual function (Atkinson 2002:32; Dutton *et al.* 2010:118).

According to Soul and Matsuba (2010:20) damage to the primary visual pathways and to the occipital lobes can have several causes and can lead to impairment of the basic functions of visual acuity, colour and contrast perception, and the detection and analysis of motion and visual fields.

Damage to the post-parietal lobe or the dorsal stream may affect accurate visual guidance, the ability to shift gaze from one part of a scene to another in identifying an object or person in a crowd, and the ability to accord selective visual attention (Dutton *et al.* 2010:118). Pathology in the bilateral posterior parietal cortex gives rise to simultanagnosia, in which there is difficulty registering the presence of any object that is not being attended to and an inability to interpret the totality of a scene despite a preserved ability to see individual portions of the whole picture. Apraxia of gaze, which is the inability to move the eyes voluntarily from one element of a scene to another despite having a normal substrate for bringing about eye movement, is usually accompanied by impaired visual guidance of movement (optic ataxia) (Dutton, Macdonald, Drummond, Said-Kasimova & Mitchell 2010:107).

Damage to the inferotemporal cortex and the ventral stream pathway impairs the ability to recognise an object (object agnosia), find a route (topographic agnosia) or recognise a person's face (prosopagnosia) – thus damaging the brain's 'visual library' (Atkinson 2002:54). Damage to the posterior parietal lobes and dorsal stream impairs the ability to overview a visual scene, identify an element within it, pay attention and draw the gaze towards a particular element, while also impairing the "online" subconscious visual guidance of movement of the body through the three-dimensional world (Dutton *et al.* 2010:117). According to Hyvarinen (2004:2/5) the visual images that a person sees are more a composition of this geniculostriate projection and its cortical elaborations than a representation of the physical world.

B. Tectal pathway

Retinal fibres from both eyes enter each optical tract and project to the pretectal area of the midbrain, using inputs from the retina to produce pupillary response, whereas

the superior colliculus uses its input to generate eye movements (Mason & Kandel 1991:424).

Shining a light into one eye causes constriction of the pupil in that eye (direct response), as well as in the other eye (consensual response) (Erhardt 1990:10; Van Hof-van Duin & Mohn 1984:94). The cells in the pretectal area project bilaterally to preganglionic parasympathetic neurons in the Edinger-Westphal nucleus, which lies immediately adjacent to the neurons of the oculomotor nucleus and sends axons from the brainstem in the oculomotor nerve to innervate the ciliary ganglion (Simpson 1984:13). This ganglion contains the postganglionic neurons that innervate muscles of the iris, and constriction is entirely subcortical (Riordan-Eva & Hoyt 1999:267).

During accommodation, not only does the lens focus, but the pupil constricts as well (Erhardt 1990:10). The pupillary reactions are clinically important, because they indicate the functional state of the afferent and efferent pathways mediating them, and failure of pupil constriction in one or both eyes is likely to indicate severe neurological problems (Atkinson 2002:21). Prechtl (1984:14) states that the consensual and direct pupillary light reactions develop at the same time and are present by 31 weeks of gestational age.

C. The superior Colliculus

Some fibres of the optic nerve travel via the tectal pathway to send secondary collateral branches to visual areas of the brainstem, primarily to the superior colliculus (Hoyt 2003:369). The superior colliculus coordinates visual, somatic and auditory information that serves to adjust head and eye movements toward a stimulus (Everling, Dorris, Klein & Munoz 1999:2740). The collicular system functions to integrate the visual world with the world of the body (Beatty 1995:168). The superior colliculus helps to direct the gaze to objects that appear suddenly in the visual periphery (Soul & Matsuba 2010:18). Interconnections from the superior colliculus connect to the pulvinar, which assists with visual attention and projects to the parietal cortex that controls the functions related to the perception of space and hand-eye coordination (Atkinson 2002:110).

Since there are two different pathways to the cortex, the possibility exists that even if there is a problem with the optic radiation or primary visual cortex, information will

still be able to get through to the cortical cortex via the tectal pathway for cortical functions (Atkinson 2002:155). Goodale (2010:8) emphasises that almost all the subcortical structures mentioned above receive not only direct input from the retina, but also inputs from other visual structures, including visual areas of the cerebral cortex. The superior colliculus, pulvinar, pretectal nuclei and lateral geniculate nucleus therefore all receive inputs from area V1.

In addition, the subcortical areas are highly interconnected, and many receive input from other modalities, with each structure playing a critical role in the control of a particular set of visually guided and/or visually modulated patterns of behaviour (Schneck 2010:375). This is an 'online' process that occurs automatically, accurately and rapidly without conscious awareness, and since it is not founded in memory it allows for immediate interaction with one's surroundings (Dutton 2008:26; Dutton *et al.* 2010:117).

Any damage to or malfunctioning of the retrogeniculate and tectal visual pathways may be defined as cerebral visual impairment (CVI) (Fazzi *et al.* 2010:194; Hoyt 2003:369; Hyvärinen 2004:2/2). Dutton and Bax (2010:2) describe CVI as a visual disturbance on account of oculomotor incoordination, with visual, cognitive and perceptual impairments owing to pathology affecting the visual association cortices and their interconnecting pathways.

Cerebral palsy and CVI share a common origin and there is sufficient evidence that visual disorders, peripheral and/or central, fall very much within the spectrum of CP comorbidity (Fazzi *et al.* 2010:194; Ghasia *et al.* 2008:572).

Fazzi *et al.* (2010:194) state that the aetiology of CVI can vary (cerebral malformations, embryogenic and foetal infections, cranial traumas, degenerative encephalopathy), with the most frequent cause being pre-perinatal hypoxia-ischaemic damage, which involves not only the descending motor pathways leading to CP, but also the geniculate and extrageniculate visual pathways and the visual associative areas. According to Geddie *et al.* (2013:172), another lesion that explains the relationship between CP and CVI is periventricular leucomalacia (PVL), where damage to the subplate neurons disrupts the development of the cortical architecture. It is therefore difficult to disregard vision in CP due to the damage of the same areas as seen in CVI.

With regard to the functional organisation of the central visual pathways, Alexander (1990:374), Good, Jan, Burden, Skoczenski and Candy (2001:57), Groeneveld, Jan and Leader (1990:11) and Hoyt (2003:369) find that a large proportion of the brain is devoted to vision. As such, having an understanding of the functional organisation will help the OT to identify what is interfering with the child's functional capabilities and provide treatment focused on both the perceptual and action components of movement.

Eye movements are described in the next section

2.7.3 THE OCULAR MOTOR SYSTEM

With eye movements and postural alignment as the focus of this study, the discussion now turns to voluntary and involuntary eye movements. Disorders related to eye movements are an important diagnostic and management concern due to their effect on the functional capability of an individual (Scheiman 1997:83). Lane (2005:18) states that the function of eye movements goes well beyond vision to reflect higher brain function.

Eye movements are the fastest and most frequent movements made by the human body and are controlled by systems that are complex, sophisticated and advanced (Lane 2005:18). Although it is possible to detect objects across a large field of vision, optimal sight occurs at the centre of the retina, the fovea and represents central vision (Schneck 2010:374). Since vision is clearest at this central point, the individual needs to move his eyes to ensure the image of regard falls on the central vision and once the target is found the image on the retina needs to be stabilised, even when the head moves (Leat, Shute & Westall 1999:287).

2.7.3.1 Fixation

Visual fixation on a stationary object is a prerequisite for other eye movements such as shifting the gaze between objects (scanning) or tracking (Schneck 2010:375). Erhardt (1990:54) describes fixation as 'grasping of the eyes'. The eyes need to fixate in order to take in visual information for purposes of recognition, and the amount of visual information available to the brain during fixation is known as the span of recognition (Lane 2005:72). Variable eye misalignments can be seen in early

infancy but these misalignments should diminish over time, as the eyes become absolutely straight at three months of age (Geddie *et al.* 2013:174). Considerable development occurs from birth to six months and at one month the infant uses an immature fixate, can briefly track and towards the end of the second month, accommodation, convergence, shifting and tracking are established (Hyvärinen 1988:13; Hyvärinen 2010:265; Hyvärinen & Lindstedt 1981:17).

Each eye is moved by the coordinated actions of six extraocular muscles (Schneck 2010:375), consisting of three complimentary pairs of muscles, namely the four rectus muscles (superior, inferior, lateral and medial) and the two oblique muscles (superior and inferior). These actions can be described as follows: The lateral rectus rotates the eye outward (abduction), the medial rectus rotates the eye inward (adduction), the superior rectus turns the eye upward (elevation), the inferior rectus turns the eye downward (depression), the superior oblique muscle moves the eye both downward and inward (intorsion) toward the nose, and the inferior oblique muscle moves the eye upward and outward (extorsion) toward the temple (Mokoko & König 2011:17).

The *eye position* and *velocity* are signalled by extraocular motor neurons; the lateral rectus is innervated by the motor neurons of the abducens nucleus (cranial nerve nucleus VI), while the medial, inferior and superior recti and the inferior oblique muscles are innervated by the ocular motor neurons forming the oculomotor nucleus (cranial nerve nucleus III). The levatorpalpebrae elevating the eyelid and the ciliary muscle constricting the pupil are also innervated by the fibres travelling in the oculomotor nerve, while the superior oblique muscle is innervated by the trochlear nucleus (cranial nerve nucleus IV) (Donaldson 2000:1685; Mokoko & König 2011:17).

Lesions of the extraocular muscles, motor neurons and/or nerves lead to impaired eye movements, double vision, muscle imbalance, drooping eyelids, pupillary dilation, skew deviation (eyes at different vertical positions in the orbit), torsional deficits or head tilt (Goldberg, Eggers & Gouras 1991:667).

For conjugate movements, both eyes are yoked together (move together), which requires each pair of muscles in one eye to have a functional complement in the other orbit that can move the eye in the same plane but in the opposite direction (Leat *et al.*

1999:289). Disjunctive movement or vergence occurs when the angle between the visual axes changes and the eyes move in opposite directions when looking at an approaching object.

Binocular eye movement requires coordination among the 12 muscles and is always described in terms of where the eyes are pointing. Eye alignment is a prerequisite for binocular vision (Day 1997:17). Schneck (2010: 375) states that for binocular fusion to occur, both eyes must be aligned on the object of regard in a process known as motor fusion, which requires coordination of the six extraocular muscles of each eye and precision between both eyes. All children except the very anxious or inattentive, should be able to sustain precise fixation with no observable movement of the eyes for six-ten seconds (Scheimann 2002:8). Sensory fusion relates to the visual system's ability to combine similar information, size and clarity from each eye into a single image, and problems with either alignment or refractive equality will result in binocular vision disorders (Scheiman 1997:68).

A loss of eye alignment is referred to as strabismus and may indicate a marked refractive error in one eye, known as amblyopia, which is not an optical problem but rather a neurophysiological one related to the visual pathways (Scheiman 1997: 68).

Saavedra *et al.* (2010:21) suggest that the improvement of visual motor skills, specifically fixation, may contribute to improved head stability and thus improved postural control in children with CP.

There are two systems that work to stabilise the eye during head movements, namely the vestibulo-ocular response that stabilises images on the fovea during brief head movements, and the optokinetic response that holds images in place during sustained head rotation (Goldberg *et al.* 1991:661).

2.7.3.1.1 Vestibulo-ocular response

The vestibular sensory organ consists of semicircular canals, which detect the rotation of the head, and otoliths, which sense the linear movement and orientation of the head with respect to gravity (Parham & Mailloux 2010:330). During head movements in any direction, the semicircular canals of the vestibular labyrinth signal the rate at which the head is rotating, while the oculomotor system responds to this

signal by rotating the eyes at an equal and opposite velocity to maintain the visual image on the retina (Riordan-Eva & Hoyt 1999:270). Neurons in the vestibular nuclei project to the motor nuclei in such a way that the inputs from each canal excite and inhibit complementary muscles in both eyes when stimulated. Eyes remain still when the head is stationary because the various charges from all 12 muscles and six canals are in balance. If nystagmus is present when the head is still it is an indicator of a disease of the labyrinth and its central connections (DeGangi 1994; Kelly 1991:503).

The purpose of this eye movement response is to minimise eye movements relative to the visual environment – in other words, the stability of the eyes with respect to the visual environment is closely maintained to stabilise the image on the retina (Kelly 1991:503).

When an infant turns its head in any direction, its eyes appear to move in the opposite direction, but this actually demonstrates a delayed response to moving with the head and gradually diminishes until it is integrated by three months of age. This response may act as a mechanism for elongating the ocular muscles in preparation for controlled movements (Erhardt 1990:34).

2.7.3.1.2 Optokinetic nystagmus (OKN)

Motion sensitivity is one of the first visual functions to develop. Infants prefer to look at moving objects rather than static displays, which serves as evidence of early directionality through the optokinetic system operated by the subcortical system in the newborn and supplemented by the cortical system at about three months of age (Atkinson 2002:74). A visual scene moving in a particular direction across the field of vision evokes involuntary, conjugate, rhythmical eye movements known as optokinetic nystagmus (OKN). The OKN, already present at about five days after birth, is based on the fact the eyes tend to follow or track the motion of one element at a time in steadily moving display (activating the pursuit pathways) and as the tracked element moves out of sight, the eyes will ‘snap back’ (called saccades) to fixate and follow another one (Leat *et al.* 1999:294).

The purpose of OKN is to minimise the motion of the moving environment upon the retina in order to maintain a clear image. Abnormal binocular experience occurring

in the first year of life can have an effect on OKN (Leat *et al.* 1999:295). Any deviation or absence of this response indicates a subcortical and/or cortical dysfunction, with abnormal optokinetic nystagmus in the form of asymmetrical binocular optokinetic nystagmus showing impairment in the direction of the most damaged hemisphere (Fazzi *et al.* 2010:198).

2.7.3.2 Saccades

Voluntary saccades are initiated in the frontal lobe (frontal eye-field area 8) and descend through the basal ganglion and the anterior limb of the internal capsule into the brainstem, terminating in the midbrain pretectal area (Riordan-Eva & Hoyt 1999:270). Humans make an average of three saccades per second, whether doing something that requires moving the fovea, such as reading, or doing something for which vision is irrelevant, such as thinking about a conversation (Dilts 1998:2/4; Goldberg *et al.* 1991:674).

Saccadic or scanning movements are the fastest eye movements and are defined as a rapid change of fixation from one point in the visual field to another (Schneck 2010:375). The generation of a saccade involves a pulse of increased innervation to move the eye in the required direction, and a step to maintain the new position in the orbit by counteracting the visco-elastic forces working to return the eye to the primary position (Lane 2005:21; Riordan-Eva & Hoyt 1999:270). According to Lane (2005:21), it appears that the cerebellum calibrates both the amplitude of the saccades as well as the pulse step, and the command contains information on not only the speed, but also the direction and final position. The role of sensory receptors in eye muscles is not well understood, but there is physiological and clinical evidence for the presence of proprioceptive signals in many areas of the central nervous system. However, it is unclear which structures generate these sensory signals, and which central neural pathways are involved (Ruskell 1989:199).

Inaccuracy most commonly occurs when the saccades are executed but miss the target by falling short or extending past it, or when there is a mismatch between the pulse and the step that causes a flicker at the end of a saccade, which is sometimes mislabelled as nystagmus (Scheiman 1997:85; Scheiman 2002).

Leat *et al.* (1999:297) state that although anatomical structures may be functional early in life, increased latency to peripheral targets and poorly formed saccades might result from a number of factors such as poor attention, reduced arousal, impaired cognitive factors, and noisy neural activity in the peripheral retina of infants.

Observations of gaze-shifting dysfunction in children with CP have been described using a variety of terms such as uncoordinated saccades and pursuit, paroxysmal ocular deviations, stability of fixation inability, impaired fixation and eye movement, complete disruption of ocular motor organisation, dyskinetic eye movement disorder, and ocular motor apraxia (Ghasia *et al.* 2008:578). According to the results of a study by Ghasia *et al.* (2008:578), gaze dysfunction in CP presents on average in 22% of children with quadriplegia CP, 18% of children with level-3 and level-5 CP (GMFCS), and 8% of children with level-1 and level-2 CP (GMFCS).

Saccadic eye movements appear to develop between one and six months of age (Lane 2005:21). According to Erhardt (1990:45) the infant moves the eyes and head together at two months, while at six months the infant has the ability to accurately shift the eyes between targets at different focal lengths without head movement during adaptive interaction of eye-hand goal-directed activities.

2.7.3.3 Pursuit/ Tracking eye movements

Pursuit occurs when the eyes smoothly follow a visual target across a visual background (Harris 1997:912). Roman-Lantzy (2007:2/3) states that children with CVI experience difficulty when an object itself presents a complex display or when an object is viewed within an environment that presents a complex display, or when an object is viewed at the same time as other sensory or motor input and thus competes for attention. The ability to manage sensory stimuli can thus be improved through the monitoring of the visual background.

Pursuit originates in the occipital cortex and descends to the midbrain and paramedian point in the reticular formation, whereas this area also receives input from the cerebellum that drives smooth pursuit (Riordan-Eva & Hoyt 1999:271). The slow phase of OKN is likely to be generated in area V5, which involves motion detection, with this descending pathway accompanying the pathway for pursuit

(Riordan-Eva & Hoyt 1999:270). Eye movements related to pursuit enable the continuous and clear view of moving objects and are functional by seven weeks of age (Lane 2005:21). The visual pursuit or tracking system is characterised by slow, smooth movements and may occur with the eyes and head moving together or with the eyes moving independently of the head (Schenck 2010:375).

According to Erhardt (1990:45), infants as young as one month are able to track a target horizontally at 60 degrees from the periphery to midline and back to the side, albeit it in jerky movements. At two months the infant can start tracking an object circularly, losing and regaining the target and jerkily converging on it when it moves closer from middle to near space or diverting from it when it moves away from near to middle space. At four months the infant's eyes begin to move independently from the head to take in limited fields of vision to the left and right, while at five months the eyes move independently from the head to take in limited upper and lower fields of vision. At six months of age, the eyes move smoothly and conjugate in a circular direction. Controlled tracking skills progress in a developmental pattern from horizontal to vertical eye movements, followed by diagonal and lastly, circular movements (Harris 1997:912; Schneck 2010:378).

Symptoms of poor pursuit include excessive head movements during near-task work, jerky eye movements or tremors as the eye crosses the midline, and excessive loss of fixation while tracking (Lane 2005:21). According to Atkinson (2002:21) the purpose of observing smooth pursuit is to measure eye movements and visual attention, with an inability to follow being a possible indication of neurological and/or attention problems.

2.7.3.4 Nystagmus

Nystagmus is a condition characterised by involuntary, rhythmic oscillations in one or both eyes (Scheiman 1997:399).

By one to four months of age, a child should have developed the ability to fixate on objects, and any interruption of this development could result in nystagmus (Geddie *et al.* 2013:179). Reduced visual acuity is caused by an inability to maintain steady fixation, otherwise known as fixation nystagmus (Riordan-Eva & Hoyt & 1999:276). Geddie *et al.* (2013:179) state that nystagmus can be caused by a too-small optic

nerve, an underdeveloped fovea, or a variety of other abnormalities affecting the rods or cones of the eyes.

Nystagmus has been described in children with white-matter damage of immaturity (Jacobson & Flodmark 2010:32). Infections of the central nervous system could cause damage to the visual pathways and may ultimately lead to nystagmus (Soul & Matsuba 2010:23). Diseases of the labyrinth and its central connection lesions of the cerebellum could result in disorders affecting the control of eye movements (Ghez 1991:634).

Although rare, ataxia in CP caused by a lesion of the cerebellum is a disorder of reciprocal innervations, leading to difficulty in sustaining posture against gravity, grading movements in the presence of intense tremors, and controlling eye movements (Black 1982:51). According to Hoon and Tolley (2013:433), ataxia is characterised by movements that are jerky and uncoordinated and which lack the smooth flow of typical motion. Fazzi *et al.* (2010:198) find that similar to the way in which different motor patterns can be associated with different forms of CP, it is also possible to identify neurovisual characteristics typically associated with each form, linked to the site and extent of the damage, as well as the timing of the insult.

2.7.4 IMPLICATIONS FOR CEREBRAL PALSY

Occupational therapists must be aware of and understand the characteristic behaviours of CVI that are typically seen in children with CP and which are among the myriad factors restricting their participation.

The visual and postural control demands differ from task to task (Baker-Nobles 2011:17). In some cases of children with neurological motor disturbances, the most serious visual defect may be the leading and presenting symptom, particularly if the neuromuscular defect is mild. In other cases the visual defect may be overlooked because of the severity of the neuro-muscular disability. The combinations of visual and neuromuscular disabilities reduce the child's functional goal-directed tasks (Dutton 2008:13).

Geddie *et al.* (2013:435) state that visual impairments are common and diverse in CP and may entail both ocular and cerebral visual impairment conditions like

retinopathy of prematurity, nystagmus, homonymous hemianopia, strabismus and hyperopia (farsightedness).

Ghasia *et al.* (2008:572) state that the severity of visual deficiency differs in cases of mild versus severe CP. Children with the most severe CP are most at risk for myopia, absence of fusion, dyskinetic strabismus, severe gaze dysfunction and CVI, while children with milder CP or level-1 GMFCS are rarely afflicted by such deficiencies. It has been shown that children with dyskinetic CP not only have dyskinetic eye movements, but also thrust their bodies or head backwards or to the side in order to shift their gaze (Ghasia *et al.* 2008:578; Saavedra *et al.* 2010:21). Saavedra *et al.* (2010:21) also state that for children with dyskinesia, the effort of attempting to control their eye movements will result in increased movements of the body.

According to Baker-Nobles (2011:17) children with CP are most at risk for cerebral visual impairment. The clinical picture of the main forms of CP (diplegia, hemiplegia and quadriplegia) can be defined not only by specific patterns, but also by specific neuro-ophthalmology profiles that include peripheral problems such as ocular disorders (refractive errors, fundus oculi abnormalities), central problems that cover the spectrum of CVI, reduction in acuity, contrast sensitivity, as well as visual-field and oculomotor dysfunctions (Fazzi *et al.* 2010:197). The extent of impairment in acuity and visual field is often correlated with the extent of damage to the central nervous system (Soul & Matsuba 2010:41).

According to Roman-Lantzy (2007:2/17), it is important to note that CP children with CVI may coexist with ocular forms of visual impairment and that CVI may frequently go undiagnosed in the presence of a significant ocular disorder that may provide a logical explanation for the impaired vision, for example a retinal disease or retinopathy of prematurity, which may mask the characteristic effects of visual field preference. Vision can be overlooked in the presence of severely affected movements in children with CP. Since eye and motor movements can be severely affected in a child with CP, there is a need for careful analysis of the very dynamic relationship between eye movements and posture and the influence this may have on the child's participation in all aspects of life (Hyvärinen 2004:1/3).

As seen in practice by the researcher, this process has multiple implications for a child with CP who has to deal with abnormal postural tone, poor postural control,

stereotyped synergistic muscle activation, and secondary implications due to limited movement, such as contractures and deformities.

2.8 CHAPTER SUMMARY

Occupational therapy, physiotherapy and speech therapy often produce successful results amongst those with CP, even from a young age. Vision is generally the motivation for movement and the primary system of integration. CP can present with defects in the anterior part of the visual system, as well as the posterior pathways; visual processing and higher visual functioning. These are associated with numerous visual defects, such as, impaired visual fields, reduced visual guidance of movement and limited visual searching, associated with a disordered ability to make searching eye movements. Impaired recognition of the ventral stream also occurs. Impaired vision on one side due to an impaired visual field or attention may prevent the child from moving his or her eyes. This poses a challenge in terms of the therapeutic treatment of abnormal, unnecessary or limited movements and atypical tone, as postural control also interacts with the sensory systems, cognition, arousal and the environment.

In terms of eye movements and postural alignment, it can be observed that the way in which a child moves with his or her body and eyes is a reflection of the overall processing taking place in the brain. As such, eye and body movements must be interpreted with the necessary care in order to design specific treatment strategies, best suited to the individual needs of each child. By employing the elements of both the motor and visual functions, the therapeutic process is based on the principle that optimal posture depends on optimal eye movement, and *vice versa*.

CHAPTER 3

RESEARCH APPROACH AND METHODOLOGY

3.1 INTRODUCTION

The previous chapter focused on the literature fundamental to this study. The scope of this study lies in the domain of Occupational Therapy. The aims and objectives are listed for clarification as stated in Chapter 1.

This chapter is aimed at describing the methodology and includes ethical clearance and implementation obtained for the study, description of the research design, study population, sampling, pilot study, measurement instruments and methods used for collecting the data and data analysis. The following table summarises the research methodology used in this research study.

Table 3.1: Summary of research methodology

Ethical considerations	Ethical clearance was obtained from the Ethics Committee (ECUFS no. 20/40) of the Faculty of Health Sciences, University of the Free State. Permission was granted verbally, from all identified research sites. Confidentiality was maintained and participation was voluntary and informed consent was obtained. The study was performed before the act of assent came into effect.
Research design	Quantitative approach with a descriptive and correlation study design.
Study population	Children diagnosed with CP, between two and ten years.
Sampling	A non-probability, convenience sampling of 57 children who met the inclusion criteria.
Pilot study	Pilot study was undertaken to determine if any adjustments had to be made.
Data collection procedure	Structured interviews, unstructured- and structured observations of eye movements and postural alignment in sitting in the frontal plane.
Data analysis	Descriptive statistics, two-way frequency tables and non-parametric Spearman rank order coefficients.

3.1.1 AIM OF THE STUDY

The aim of the study was to describe eye movements and postural alignment and to investigate if there was a possible association between eye movements and postural

alignment in sitting in the frontal plane of children with CP between the ages of two and ten years.

3.1.2 OBJECTIVES

The research objectives were as follows:

- To describe the eye movements of children with CP.
- To describe the postural alignment of children with CP in sitting in the frontal plane.
- To establish whether an association exists between eye movements and postural alignment during sitting in the frontal plane of children with CP.

3.2 RESEARCH APPROACH AND STUDY DESIGN

As a clinician with a special interest in CP the researcher has decided to use a non-experimental, quantitative approach with a descriptive and correlation study design (Fouché & De Vos 2011:96; Delport & Roestenburg 2011:182; Fouché *et al.* 2011:155; Leedy & Ormrod 2010:182). This allowed the researcher to develop and select the variables needed to be observed and described that were suitable and applicable for cerebral palsied children to answer the aim.

A quantitative approach was used to quantify the variation of eye movements and postural alignment of children with CP as observed in the clinical setting. The researcher wanted to quantify these variations by using structured interviews as well as unstructured- and structured observations. Information was gathered using quantitative variables namely postural alignment of sitting in the frontal plane and eye movement of children with CP (Fouché *et al.* 2011:155). It may therefore be defined as an inquiry into a social or human problem, based on testing a theory composed of variables, measured with numbers and analysed with statistical procedures in order to determine whether the predictive generalisations of the theory hold true (Fouché & Delport 2011:64).

A non-experimental design is used in descriptive studies in which the units that have been selected to take part are measured on all the relevant variables at a specific time (Fouché *et al.* 2011:157).

A descriptive study provides the opportunity to describe the eye movements and alignment in body segments over the base of support against gravity and allow the researcher to generate a deeper understanding of CP (Fouché & Delpont 2011:61).

In the presence of quantifiable variables a correlation study was used to investigate the possible association between eye movements and postural alignment in children with CP (Fouché & De Vos 2011:96). The data was gathered by using structured observations (Leedy & Ormrod 2010:183; Leedy & Ormrod 2010:108; Fouché & De Vos 2011:96).

These combinations of designs were the most suitable for this research as the researcher had a particular focus for this study namely to describe eye movements and postural alignment in children with CP and to investigate the association between these variables as observed in the clinical setting. The researcher was aware that no standardised test was appropriate to assess the association between eye movements and postural alignment in children with CP. The researcher's observational skills with a special interest in CP assisted the researcher to use structured observations (Delpont & Roestenburg 2011:182) with quantifiable data that were transcribed onto the measurement instrument's sheet and coded (cf. Appendix B).

3.3 METHODOLOGY

In the following section the study population and sampling will be discussed.

3.3.1 STUDY POPULATION AND SAMPLING

Three sites were identified to collect data for this research. These included a CP clinic, a school for children with CP and a private practise in Gauteng. These sites have specialised services for children with CP. No participant was used from the researcher's practice to prevent subjectivity.

The population that was included in this study consisted of children who met the inclusion criteria over an eight month period. The participants were those who were available on the day when data was gathered and have met the inclusion criteria by means of a non-probability – convenience sampling (Strydom 2011a:222).

Inclusion criteria:

- Boys and girls
- Between two and ten years of age (exclude all children ten years one day)
- Diagnosed with CP according to a paediatrician or neurologist

The researcher has chosen the age norm between two and ten years after considering the following aspects:

- Abnormal or asymmetrical distribution of muscle tone in children with CP are likely to be influenced to the development of deformities as they getting older and the most common of these result in permanent shortening or contracture of one or more groups of muscles which limited mobility (Hoon & Tolley 2013:442). The age norm between two and ten years will provide a continuum of motor and sensory processing involvement.
- According to Sanger *et al.* (2003:e89), the term CP is used when an injury occurs in children before two years of age; and when it occurs in older children, a variety of descriptive labels have been applied, depending on the cause. The transition from infancy to early childhood occurs around two years of age and therefore childhood can be considered as being from two years of age (Dodd & Greaves 2010:96).

Due to the nature of the sampling the researcher had to spread the ages to be able to have a large enough sample for this study.

3.4 DATA COLLECTION

The standards concerning visual impairment are based on two components: visual acuity and visual fields. Although a standard or universal protocol does not exist for

a functional vision assessment it should, according to Trief and Shaw (2009:26), include the following:

- A summary of medical reports
- Observations of near and distance vision (acuity)
- Evaluation of visual field (peripheral awareness)
- Ocular motility (Saccades/shifts, binocular fixation, tracking/pursuits).

All above mentioned were used for this study except observations of near and distance vision. Ideally, visual fields, ocular motility and acuity need to be assessed in conjunction with postural alignment, but the necessary special testing material for visual acuity that can be used by OTs, is expensive and was not available at the time of the study in South-Africa. The lack of practical experience and training in the field of visual impairment was a hindrance (cf. 1.1).

The sitting assessment for children with neuromotor dysfunction (SACND) was not appropriate for this study (Reid, Schuller & Billson 1996:24). No exclusions as required by this test were upheld. By contrast, the study population for this study included children with CP even though they could not maintain sitting independently. Furthermore, the SACND observed children performing two activities with multi sensory input simultaneously. In this uniquely designed structured observation the researcher excluded any other competing activities that could impact the ability to keep the body up against gravity.

The aim in this quantitative descriptive and correlations study was to explore and describe eye movements and postural alignment in sitting in the frontal plane accurately in children with CP. This allowed the researcher to study if there was any association between eye movements and postural alignment during sitting in the frontal plane of children with CP. Table 3.2 provides an overview of the measurements instruments and –methods used in this study.

Table 3.2: Overview of measurement instruments, -methods and reasons

Description of each section in measurement instruments and –methods	Reasons
<p>Section 1: <i>Characteristics of the participant.</i></p> <p>Measurement Instrument: Questionnaire, checklist and measurement scale.</p> <p>Measurement method: Structured interview and unstructured observation.</p>	<p>The information provided the researcher with the necessary background of the child’s profile for general health and interventions received.</p>
<p>Section 2: <i>Eye movements</i></p> <p>Measurement instruments: Observed schedule.</p> <p>Measurement Method: Structured observations.</p>	<p>Fixation, following, saccades, response to peripheral and pupillary response are the foundation upon which visual processing is built and guide the movements for reach, grasp and manipulation. Visual input is an important source of information about the body’s position and movement in space with respect to gravity and the environment.</p>
<p>Section 3: <i>Characteristics for functional vision.</i></p> <p>Measurement instruments: Checklist.</p> <p>Measurement method: Unstructured observations</p>	<p>These characteristics provided the researcher a list of which visual functions are difficult for a CP child, and which function are perhaps not there at all.</p>
<p>Section 4: <i>Postural alignment</i></p> <p>Measurement instrument: Observed schedule.</p> <p>Measurement Method: Structured observations.</p>	<p>Postural control is necessary to maintain all body segments in an upright position and to orientate the eyes to the environment. We need to be able to maintain postures during tasks and have adequate head control to stabilise our head in the correct orientation. “<i>Control begins in the head segment, the first sense that is mapped to head control appears to be vision</i>” (Shumway-Cook & Woollacott 2012:221)</p>

The measurement criteria chosen for this study is applicable to the demands for function in children with CP. These measurement instruments were designed due to the lack of measurement instruments that are appropriate and affordable for this study population. Instead of looking purely at 'laboratory based ' techniques, a practical or ‘field’ knowledge was used to observe the participant acting upon the environment. A number were assigned for quantification of the observed behaviours. The measurement instruments were pilot tested for identification of any measurement errors (cf. 3.4.6) (Strydom 2011b:236). The rating scales that were developed to evaluate the behaviours of the participants were directly observed and had relied on the expertise of the researcher (Delpport & Roestenburg 2011:182) (cf. 2.6.3).

3.4.1 THE DATA COLLECTION PROCESS

The average duration to complete the execution of a session was 45 minutes.

The procedure was as follows:

- The researcher travelled for approximately 200 kilometres to the research site.
- On arrival a room was set-up according to the specifications (cf. Appendix C)
- All equipment necessary for the execution were at hand (cf. Appendix C; cf. 3.4.2.7)
- Received consent forms from the parent(s) or guardian(s) of the participant(s) that took part (cf. Appendix A)
- Session (cf. 3.4.3.)
- Recording the data during the session (cf. Appendix B)
- Feedback to parent or guardian (cf. 3.5.3).

3.4.2 MEASUREMENT INSTRUMENTS

In this section, the measurement instruments, structured interview as well as unstructured- and structured observations will be discussed and consist of describing the data relating to the child with CP, the method of collecting the data with a description. All instruments are orderly numbered to represent quantities (Delpont & Roestenburg 2011:172).

3.4.2.1 Observation schedule

An observation schedule is a coding form compiled and filled out by the researcher (Delpont & Roestenburg 2011:182). The researcher had observed eye movements and postural alignment in children with CP and assigned it to a predetermined and preplanned observational criteria consisting of a structured interview as well as structured- and unstructured observations (Leedy & Ormrod 2010:182).

3.4.2.1.1 Structured interview

A structured interview is a quantitative research method used to offer the same questions in the same order and guarantees that answers can be reliably collected and that comparisons can be made (Leedy & Ormrod 2010:188, Delpont & Roestenburg

2011:186). It has enabled the researcher to examine the variables identified for this research.

3.4.2.1.2 Structured observations

Predetermined and prestructured observation criteria were compiled to observe eye movements and postural alignment in sitting in children with CP. The variables measured were categorised into observed criteria and provided a rating continuum (Leedy & Ormrod 2010:182, Delpont & Roestenburg 2011:182). The items in the measurement were selected on the basis of both clinical relevance, potential responsiveness to change and were applicable to the population of this research (Russel, Rosenbaum, Avery & Lane 2002:5). Typical developmental milestones were documented in the literature review and these have formed the basis of the items chosen (cf. 2.6.3).

3.4.2.1.3 Unstructured observations

The researcher had recorded different behaviours as predetermined for this study. The researcher attempted to document as much as possible on all the variables pertaining to this study in order to discover particular behaviours of the participants. It was unstructured but holistic (Delpont & Roestenburg 2011:182).

3.4.2.2 Characteristics of the study population - Appendix B, section 1, number 1.

The following Table 3.3 describes the characteristics of the participant.

Table 3.3: Characteristics of the participant

Data relating to the child	Method of collecting data	Description and Why?
Ages, medical history, medication, additional impairments, special investigations.	Structured interview A questionnaire was compiled by the researcher to collect relevant biographic data.	In order to gain a detailed picture of a participant.

The following considerations were taken into account during the interviews:

All questions were posed and meaningful. The structured questions in the interview were done with the parent or guardian. If necessary an interpreter was used during the interview. Consideration was given to the environment for privacy to assure participants of absolute confidentiality before the interview began.

3.4.2.3 Eye contact, head control and upper-extremity use. Appendix B, section 1, number 2.

Table 3.4, eye contact, head control and upper-extremity were described.

Table 3.4: Data collection relating to eye contact, head control and upper-extremity

Data relating to the child	Method of collecting	Description and Why?	Numerical Coding
Eye contact	<p>Unstructured observation was used whilst the child was engaged with the parent or guardian in a stable supportive position during play.</p> <p>Magnitude recording was used to code the scale.</p>	To determine if the child has brief eye contact, sustained eye contact or no eye contact.	<p>Coding: 1-3</p> <p>1= briefly; <i>Eye contact sustained for one second.</i></p> <p>2= Yes; <i>Eye contact sustained for at least six seconds or more.</i></p> <p>3= No; <i>cannot sustain eye contact for one second.</i></p>
Head control	<p>Unstructured observations were used during play with the parent or guardian in a stable supportive position to observe head control.</p> <p>Magnitude recording was used to code the scale.</p>	To determine if child has adequate head control, an asymmetry of head or does the child need assistance to keep the head up.	<p>Coding: 1-4</p> <p>1= good control; <i>head, neck and trunk segments constitute as a unit in a vertical alignment.</i></p> <p>2= asymmetry to left; <i>head not aligned with neck and trunk.</i></p> <p>3= asymmetry to right; <i>head not aligned with neck and trunk.</i></p> <p>4 – need assistance; <i>all three segments need external support to be vertically aligned.</i></p>
Upper extremity use	<p>Unstructured observations were used during play with the parent or guardian in a stable supportive position to observe upper-extremity use when a toy was offered.</p> <p>Magnitude recording was used to code the scale.</p>	To determine if child can use hand and eye together.	<p>Coding: 1-3</p> <p>1= good; <i>sequential activation of eye, head and then hand movements.</i></p> <p>2= no accurate reach; <i>moving the arm but not grasping the object.</i></p> <p>3= no hand function for reach; <i>no shaping of fingers to grasp an object.</i></p>

Different behaviours of eye contact, head control and upper-extremity use were recorded. This measurement instrument measured more than one data item of each variable. Ordinal categories were established from absent or poor to present or good. These forms of magnitude recording involved recording the severity of behaviours (Delpont & Roestenburg 2011:184).

The term ‘*the most supportive stable position*’ can be explained as, the position the child was placed in, with maximum upright support for example on the parent’s or guardian’s lap or in the child’s adapted wheelchair.

3.4.2.4 Information regarding milestones reached – Appendix B, section 1, number 3.

Table 3.5: Description of milestones reached

Data relating to the child	Method of collecting data	Description and why?
Rolling, sitting, hands to midline, hand regard and eye contact are early key gross and fine motor milestones.	During a structured interview, questions were asked to collect relevant information regarding the milestones reached.	The various milestones on the road to walking are affected by the vertical (sitting) and horizontal (rolling) aspects. Hands to midline, eye contact and visual regard are key milestones in the development of early fine motor skills.

3.4.2.5 Information relating to visual behaviour during eye movement observations, namely fixation, following, saccades, visual response to the peripheral, pupillary response and nystagmus - Appendix B, section 2, number 1.

In Table 3.6 visual behaviour during eye movements are discussed.

Table 3.6: Visual behaviour during eye movements

Data relating to the child	Method of collecting data	Description and why?	Numerical coding (cf. Appendix B)
Fixation	Structured observation	To determine if both eyes were aligned, lost the alignment, brief or absent.	Coding 1-5: <i>Where 1 indicates good and 5 poor</i>
Following	Structured observation	To determine if following was accurately or followed with preferential material or within his own interesting space or is response absent.	Coding 1-5: <i>Where 1 indicates good and 5 poor</i>
Saccades	Structured observation	To determine if under or over shooting was present or only if midline was crossed. If moderate or large movement of the head and body were observed during saccades.	Coding 1-5: <i>Where 1 indicates good and 5 poor</i>
Visual response to peripheral	Structured observation	To determine if the visual awareness distance and space were in the expected peripheral sphere or if response was delayed. Observations for differences between halves right and left and up and down were scored.	Coding 1-4: <i>Where 1 indicates good and 4 poor</i>
Pupillary response	Structured observation	To determine if response was consensual, different or absent.	Coding 1-3: <i>1- consensual response</i> <i>2- pupils different</i> <i>3- no response</i>
Nystagmus	Structured observation	To determine if spontaneous or fixation nystagmus were present.	Coding: 1-3: <i>1- absent</i> <i>2- with fixation</i> <i>3- present</i>

The following considerations were taken into account during the structured observation schedules:

A well illuminated room was allocated for the researcher at each research site. The observational area was quiet, free from external distractions and had the necessary space and equipment (cf. Appendix C) The researcher should ensure that children with poor head and trunk control have appropriate support by using their adaptive chair and if the child was not equip with a supportive seat a supportive position in supine was used. Symmetrical and the most stable starting position was a requirement (cf. Appendix C).

3.4.2.6 Information relating to general visual observations, namely appearance, vision function, mobility skills and improved visual performances – Appendix B, section 3, number 1.

Table 3.7 describes the characteristics of cerebral visual impairment observed.

Table 3.7: Characteristics of cerebral visual impairment

Data relating to the child	Method of collecting data	Description and Why?
General visual characteristics	Unstructured observations The characteristics of cerebral visual impairment checklist compiled by Appleby (2002:22) were observed. A check was made next to the characteristics that pertain to the child with CP. A checklist usually does not have a built in rating scale and a check indicates adherence to given criteria (Delpont & Roestenburg 2011:203).	The researcher interpreted the unstructured observations and formed an opinion and judgment about the characteristics of CVI.

**3.4.2.7 Information relating to observation of postural alignment in sitting –
Appendix B, section 4, number 1.**

Table 3.8 describes postural alignment in sitting.

Table 3.8: Postural alignment in sitting

Data relating to the child	Method of collecting data	Description and Why?	Numerical coding
Postural alignment in sitting	<p>Structured observations. The variables for sitting were measured in the frontal plane and a score was assigned according to the structured observations. The following scoring criteria were used for sitting on a bench.</p> <p>a. The head aligned with the trunk, in the midline, and level in the horizontal plane (not tilted forward, backward, or sideways)</p> <p>b. The pelvis in a relatively neutral position (not tilted anteriorly, posteriorly or laterally)</p> <p>c. The feet placed on the floor in alignment with the knees (not pulled under the seat, or thrust forward, or out to the sides)</p>	To determine if any postural deviations were present in sitting	<p>Score 1: <i>was assigned for no deviations.</i> Score 2: <i>if one criterion was missing.</i> Score 3: <i>if two criteria were missing.</i> Score 4: <i>if all criteria were missing.</i></p>

The following considerations were taken into account during the structured observation schedules:

The child was sitting on a bench without arm and back supports with feet touching the floor. The bench was adjustable to accommodate the height. The 90.90.90 (cf. 2.6.1) sitting principle was used, ninety degrees at the hips, ninety degrees at the knees and ninety degrees at the ankle. The child was placed with the head in the midline and the trunk as straight as possible on a bench next to the parent or guardian. The support was only withdrawn when the child felt comfortable without crying.

3.4.3 DATA ANALYSIS

The researcher made an inquiry into a phenomenon based on testing a research question about quantitative variables, quantified as ordinal Likert scale numbers indicating the degree of individual differences in postural alignment and eye movement and analysed with statistical procedures in order to determine whether there was an association between the relevant groups of variables. The researcher did not want to merely report data, but rather reduce data to an intelligible and

interpretable form so that the associations of research problems can be studied and conclusions drawn (Fouché & Bartley 2011:249). The data were collected by means of structured interviews, unstructured observations and structured observations, transcribed on the instrument measurement sheet and coded by the researcher for analysis by computer. All data capturing and analysis were conducted by the Department of Statistics, University of North-West.

The researcher had used structured observation schedules as the main measurement for collecting the data to describe the variables identified in children with CP. The researcher's preplanned and prestructured data were coded in ordinal Likert scale numbers that allowed the researcher to use descriptive statistics, two-way frequency tables and non-parametric Spearman rank order correlation coefficients to determine whether an association exists between eye movements and postural alignment in children with CP (Ellis & Steyn 2003:51).

Descriptive statistics were used as the study was non-experimental and descriptive in design. At first the researcher described what the data was and what the data showed. Descriptive statistics are procedures that describe numerical data in that they assist in organising, summarising and interpreting sample data (Fouché & Bartley 2011:251). Results were summarised in terms of frequencies, percentages, means and standard deviations.

Associations between variables among the children with CP were observed. The statistics is called Spearman rank order correlation coefficients and indicate the direction and strength of the relationship (Leedy & Ormond 2010:273; Ellis & Steyn 2003:51). The Spearman rank order correlation was used to determine the association between postural alignment and eye movements in children with CP. Both variables involved rank-ordered data that were ordinal in nature. The Statistica program (data analysis software system, version 10) was used for analysis (Stat soft 2011).

3.4.4 PILOT STUDY

A pilot study was undertaken to gather knowledge regarding the measurement methods and – instruments of evaluation and the conditions necessary to conduct the research. The goal was to determine whether the pilot study can be up scaled to

examine and apply the research question, methodology, and data collection techniques as used for the main study (Strydom 2011b:237).

- The number of participants for the pilot study consisted of three children diagnosed with CP according to a paediatrician or neurologist. They were selected from the three sites identified for the study; one participant age nine years from a school for CP, one participant age six years for a CP clinic and one participant age two years from a private practice specialising in CP. The age norm between two and ten years will provide a continuum of motor involvement.
- Verbal permission was obtained from the Head OT of each site to conduct the pilot study. Consent was obtained from the parent or guardian of each participant to take part in this study (cf. 3.5)

The pilot study permitted a thorough check of the planned methods for collecting the data, measurement instruments used to collect the data, statistical and analytical procedures for analysis. No alterations were made in the data collecting methods and measurement instruments. The data collected from this pilot study was not included in the data for the study population.

The steps that have been followed to conduct the pilot study to test all possible errors are identical to the main study.

3.4.5 ERRORS OF MEASUREMENT

The data produced from this study was not necessarily free from errors. Estimated errors associated with descriptive and correlation data were identified by the researcher before the data was collected and are included in Table 3.9 below.

Table 3.9: Methodological and measurement errors

Possible Errors	Steps to limit the effect of mentioned error
To find a statistical association between two variables depends on how well those characteristics have been measured (Leedy & Ormrod 2010:275)	The chosen criteria for scoring the observed behaviors were precise with clear distinct significant numerical variables.
Collect data injudiciously	The researcher's experience in the clinical field for more than 25 years with a special interest in CP children assisted the therapist to collect the structured observational data judiciously.
Not measuring the content	The researcher qualified as a Senior Occupational Bobath/Neuro-developmental Tutor lecturing this concept locally and international. The two main variables postural alignment and eye movements in children with CP are well studied by the researcher.
Bias undermines the internal validity of research	The well prepared preplanned and prestructured measurement data allowed the researcher to collect the data. This structured observation had minimised the errors. The observational schedule assists to gathered information in the same way.
Data processing	All data capture and analysis were conducted by the Department of Statistics, University of North-West.
Factors influencing the results	Through clinical observations and reasoning, the therapist could provide external support during eye movement observations according to the needs of the child as a symmetrical and most stable starting position was a requirement.
Measuring instrument	During the pilot study the researcher tested the measuring instrument that was utilised during the study. No changes had to be made to the measuring instrument, recording sheet or informed consent.
Collecting data from the researcher's practice	No respondents were used from researcher's practice to prevent any subjectivity.
The toys/objects used for study could have influenced the child's participation, playfulness, attention and engagement.	If the child did not respond to the objects used for the study (cf. Appendix C), objects or toys were used brought with the parent or guardian, if available.

3.5 ETHICAL CONSIDERATIONS

Ethical guidelines according to the classification of ethical issues were followed (Strydom 2011:115).

3.5.1 ETHICAL CLEARANCE AND PERMISSION

Ethical approval was obtained from the Ethics Committee (ECUFS no. 20/40) of the Faculty of Health Sciences, University of the Free State before commencement of the study. Guidelines for ethical and responsible conduct were followed during the planning and execution of this study (Leedy & Ormrod 2010:101). Verbal permission was granted from the identified research sites. The Head OT of each site

obtained the necessary clearance and permission from the institution to conduct the research study.

3.5.2 AVOIDANCE OF HARM

Children with CP may fear movement due to the lack of postural control. The researcher provided external support to assist children with physical support if the child feels unsafe. The support was only withdrawn to observe postural alignment in sitting when the child felt comfortable without crying. The parent or guardian was seated close to the participant in a close guarding position to prevent falls during observations.

The participants were not put at risk and all equipment necessary for this study was not hazardous. The researcher established goodwill and co-operation, solve problems of a practical kind, and constantly kept ethical considerations in mind with respect to the research, the participants and parents or guardians.

3.5.3 INFORMED CONSENT

The informed consent form was accompanied by an information letter about the study in English and Tswana according to their preference (Appendix A). The information letter was based on the guidelines for informed consent as prescribed by the general guidelines of the Ethics Committee of the Faculty of Health Science at the University of Free State. The information letter informed parents or guardians that all the data will be only used for research and future publications. The information letter consisted of:

- A brief description of the nature of the study.
- A description of what participation involved.
- All responses remained confidential and coded.
- The study was free, voluntary and that they were allowed to withdraw from the study at any stage should they wish to do so.
- No remuneration was offered.
- There were no risks associated with participation.
- The contact information of the researcher was made available to all

participants' parent or guardian in case they required additional information of the research study.

The signed consent form completed by the parent or guardian was obtained by the OT before the commencement of the study. The study was performed before the act of assent came into effect. Upon completion of collected data the researcher invited the parent and or guardian to ask any questions. If questions were asked the researcher gave immediate verbal feedback. Applicable explanations were given to the parent or guardian on the observed behaviours. The necessary guidelines on objects that were more suitable for the hands and eyes were recommended including adaptations to the environment and/or positioning. The contact details of the researcher were made available to the participants' parent of guardian for any intervention strategies or further inquiries, if needed.

Confidentiality was guaranteed in that the measurement sheet was completed by coding. Any other information on the performance or results of the participants was handled confidentially. The researcher gave clear instructions and the procedures of observations were explained to the parent or guardian. An interpreter proficient in the applicable African language was available throughout the study. The data was collected by means of a structured interview, unstructured observations and structured observations and were dealt with in a strictly confidential manner, transcribed on an instrument measurement sheet and coded by the researcher for analysis by computer. All data capturing and analysis were conducted by the Department of Statistics, University of North-West. No sponsors were involved for this study.

As a member of the Health Professions Council of SouthAfrica, Occupational Therapy Association of South-Africa, Occupational Therapy Board of Australia as well as a member of the SouthAfrican Neuro-Developmental Association of South-Africa the researcher undertook to abide by the ethical principles of the profession.

3.6 CHAPTER SUMMARY

This chapter explained the reasons for the choice of the research methodology, and described the measurements methods and –instruments. For this study 57 children with CP between the ages of two and ten years were investigated using a non-

probability convenience sampling. Structured observation schedules were used to observe eye movements and postural alignment in children with CP. The scored structured observation schedules provided statistical data pertaining to eye movements and postural alignment in children with CP. The results from all the data are presented separate in the following chapter.

CHAPTER 4

RESULTS

4.1 INTRODUCTION

In Chapter 3, the research methodology was discussed. A quantitative approach was followed with a descriptive and correlation study design. In this chapter, the results gained from structured interviews as well as structured and unstructured observations will be presented. Frequencies, percentages, means and standard deviations were used to present the results. The aim of the study was to describe eye movements and postural alignment and to investigate if there was a possible association between eye movements and postural alignment in sitting in the frontal plane of children with CP between the ages of two and ten years.

This chapter will be presented in four sections.

- Characteristics of the study population gained from the structured interviews and unstructured observations
- Description of eye movements gained from the structured observations
- Description of postural alignment in sitting in the frontal plane gained from the structured observations
- The association between eye movements and postural alignment in sitting in the frontal plane in children with CP.

4.2 CHARACTERISTICS OF CEREBRAL PALSIED CHILDREN

In the following section the ages, accompanied impairments, previous treatment received, investigation, milestones, examination and medication will be discussed. All the data collected for analysis for the above demographics were collected by verbal response during the interview(s) with the parent(s) or guardian(s). The demographic details were limited in some cases due to children not residing to their birth parents and/or not having reports available.

The remainder of the results for this section, represent the study population and consist of the sub-classification system for CP and unstructured observations for eye contact, head control and upper-extremity use.

4.2.1 AGE GROUP

In Table 4.1, the age range for this study will be discussed. Fifty seven participants participated in this study. Two (3.50%) participants did not report their age as the date of birth of two children was unknown to the guardians.

Table 4.1: Ages of the children (n=55)

Ages of children	n	Percent
2 - 3 yrs	6	10.9
3 - 4 yrs	8	14.54
4 - 5 yrs	6	10.9
5 - 6 yrs	11	20
6 - 7 yrs	7	12.72
7 - 8 yrs	5	9.09
8 - 9 yrs	5	9.09
9 - 10yrs	7	12.72

The children, boys or girls, included in the sample population of this study were between the ages of two and ten years. Just over a half of the participants (54.38%) were six years and younger. The mean age of the participants was 5.38 years (Standard deviation = 2.26).

4.2.2 CLASSIFICATION OF CEREBRAL PALSY

Individuals with CP are grouped by the predominant type of motor disorders with a mix category available in those cases when no one type dominates. The extent of observed tonal abnormalities as well as movement disorders and typology, determine the clinical subtype of CP and is listed in Table 4.2.

Table 4.2: Sub-types of cerebral palsy (n=57)

Subtypes of cerebral palsy	n	Percent
Dystonia	3	5.26
Spastic Quadriplegia	6	10.52
Spastic Diplegia	12	21.05
Spastic Hemiplegia	8	14.03
Athetoid	3	5.26
Ataxia	1	1.75
Mixed cerebral palsy	24	42.1

Twenty four participants (42.1%) had mixed CP. A mixed presentation can be defined when more than one type of motor disorder can be present in an individual (Dodd & Imms 2010:10) (cf. 2.3.4). Twelve participants (21.05%) had spastic diplegia and eight (14.03%) participants had spastic hemiplegia CP. Six participants (10.52%) had spastic quadriplegia and less than 10% had dystonia (n=3), athetosis (n=3) and ataxia (n=1).

4.2.3 ACCOMPANIED IMPAIRMENTS

In addition to the motor and posture movement, people with CP often show other neurodevelopment disorders or impairments (cf. 2.7.2).

Table 4.3: Accompanied impairments (n=23)

Accompanied impairments	n	Percent
Epilepsy	19	82.6
Hearing Impairment	1	4.34
Visual impairment (3)		13.04
-Choroiditis	1	
-Cataract	1	
-Retinopathy of prematurity	1	

Of the twenty three participants (40.35%), where the available information concerning accompanied impairments was reported, the results were as follows: nineteen of the twenty three participants (82.60%) presented with epilepsy, one participant (4.34%) with a hearing impairment and three participants (13.04%) with visual impairment. The additional impairments were not all recorded as information were limited in some cases due to children not residing to their birth parents and/or not having reports available

4.2.4 THERAPEUTIC INTERVENTIONS

The data for specific intervention strategies previous received are shown in Table 4.4.

Table 4.4: Previous treatments received (n=39)

Previous Treatments received	n	Percent
Physiotherapy	3	7.69
Occupational therapy	3	7.69
All three disciplines (PT, OT, ST)	29	74.35
Botulinum (Botox) Injection	1	2.56
Surgery	3	7.69

Information was obtained from thirty nine participants (68.42%) whom have received some kind of intervention. Of the thirty nine participants twenty nine participants (74.35%) had attended therapy from all three therapeutic disciplines namely, occupational therapy (OT), speech therapy (ST) and physiotherapy (PT). Six participants had received either occupational therapy intervention (n=3) or physiotherapy (n=3). Three participants (7.69%) had surgery for the lower extremities and one participant (2.56%) had received botulinum toxin for the lower extremities. At the time of the study 18 participants had not received any intervention.

4.2.5 MEDICAL EXAMINATIONS

Information was obtained from thirty two participants (56.15%) for analysis. Of the remainder twenty five participants (43.85%) no information was available. The following data demonstrates the medical examinations done on participants in this study.

Table 4.5: Medical examination and investigation (n=32)

Medical examination and investigation on children with cerebral palsy	n	Percent
Eye-examination	13	40.62
Hearing examination	1	3.12
Brain Scan (MRI)	7	21.87
Hips: X-rays	1	3.12
Neurology (EEG)	10	31.25

Of the thirty two participants (56.14%) thirteen participants (40.62%) had an eye-examination, seven participants (21.87%) had received Magnetic Resonance Imaging (MRI) investigation and ten participants (31.25%) had received an Electrocephalogram (EEG) investigation. One child (3.12%) had received a radiology investigation for hips and one participant (3.12%) had received a hearing examination.

4.2.6 MEDICATION

The following medication was prescribed.

Table 4.6: Prescribed Medication (n=30)

Medication used	n	Percent
Epilim	13	43.33
Phenobarb	3	10
Rivotral	1	3.33
Tegretol	3	10
Ritalin	1	3.33
Lamincton	2	6.66
Epilim and Rivotral	5	16.66
Epilim and Lamincton	1	3.33
Convulex	1	3.33

Of the study population (n=57) thirty participants (52.63%) were on medication therapy of whom 96.66% had received anti-convulsion therapy and one participant (3.33%), Ritalin, for attention deficit disorder. Epilim was the most commonly prescribed medication for seizures.

4.2.7 UNSTRUCTURED OBSERVATION FOR EYE CONTACT, HEAD

CONTROL AND UPPER-EXTREMITY USE

The following results give an overview of the participant's eye contact, head control and upper-extremity use.

Table 4.7: Unstructured observations for eye contact, head control and upper-extremity use (n=57)

Unstructured observations for eye contact, head control and upper extremity use	n	Percentage
<u>Eye contact:</u>		
1. Briefly	23	40.35
2. Yes	29	50.88
3. No	5	8.77
<u>Head Control:</u>		
1. Good control in all planes	30	52.63
2. Asymmetry to left	4	7.02
3. Asymmetry to right	5	8.77
4. Need assistance to keep head straight up	18	31.58
<u>Upper Extremity use:</u>		
1. Reach with grasp	29	50.88
2. Objects are offered, but does not grasp	9	15.78
3. No adequate hand function to grasp	19	33.33

Twenty nine participants (50.88%) made eye contact, five participants (8.77%) did not make eye contact and the remaining twenty three participants (40.35%) eye contact was brief that means that they cannot keep fixation for six seconds (cf. 2.7.3.1.).

Table 4.7 also shows that thirty participants (52.63%) head control was good in all planes observed during play with the parent or guardian in a supportive stable position. Eighteen participants (31.58%) needed assistance to keep his/her head up. Nine participants (15.78%) had an asymmetry to the left or right.

Table 4.7 shows the upper-extremity use of the participants. Twenty nine participants (50.88%) reached with a grasp. Nineteen participants (33.33%) had no adequate hand function to grasp. Nine participants (15.78%) did not reach although objects were offered.

4.2.8 MOTOR MILESTONES

The following milestones were recorded by the questionnaire: eye contact, hand regard, hands to midline, rolling and independent sitting. It is important to recognise when a child may not be developing at typical expected age. Although each

milestone has an age level, the actual age when a typical developing child reaches that milestone can vary quite a bit (Dormans & Pellegrino 1998:30). Figure 4.1 describes if the milestones were reached or not reached, followed by a detailed description of each milestone separately.

Thirteen guardians (22.80%) did not complete this section as the information was unknown to the guardian and this means that forty four (77.19%) of completed questionnaires were available for analysis.

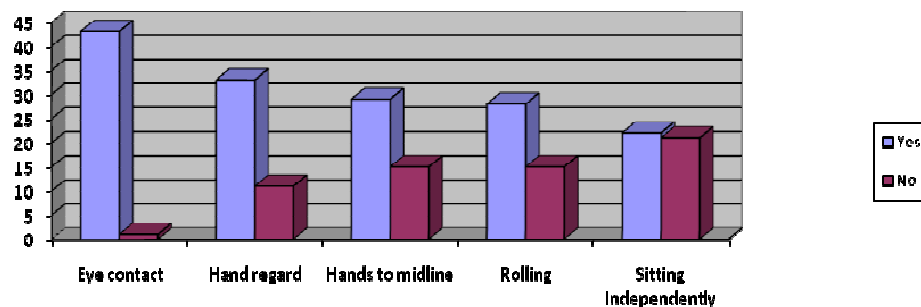


Figure 4.1: Milestones reached (n=44)

It is important to note that the results in Figure 4.1 do not describe the quality of milestones. The milestones ‘eye contact’ (97.72%) and ‘hand regard’ (75.00%) were mastered by the majority of participants. More than half of the participants have mastered the milestones ‘hands to midline’ (65.90%) as well as rolling (65.90%). Just over half of the participants sat independently (52.27%). These figures indicated that children with CP had significant motor delay. (cf. Figure 4.1).

4.2.8.1 Eye contact (n=44)

The following Table 4.8 demonstrates a developmental ladder of the milestone, eye contact, mastered by forty three participants (97.72%). One (2.27%) participant has not mastered this milestone.

Table 4.8: Milestone: Eye contact mastered (n=43)

Participants (Eye-contact)	9	6	4	6	6	2	1	3	4	1	1
Months	1	2	3	4	6	8	9	10	12	18	30


 DELAYED


In Table 4.8 the ages of participants when this milestone was mastered are shown. Infants between 6–8 weeks have the ability to make eye contact (cf. 2.7.3.1). Fifteen participants (34.88%) have mastered this milestone at expected age and twenty eight participants (65.11%) showed a remarkable delay comparing to typical development.

4.2.8.2. Hand regard (n=44)

The following Table 4.9 demonstrates a developmental ladder of the milestone, hand regard, mastered by 33 participants (75.00%). Eleven (25.00%) participants have not mastered this milestone.

Table 4.9: Milestones: Hand regard mastered (n=33)

Participants (Hand regard)	3	4	6	3	5	3	2	1	2	1	1	1	1
Months	2	3	4	5	6	8	9	10	12	15	18	24	48



 DELAYED


In Table 4.9 the ages when this milestone was reached are shown. This developmental milestone can normally be observed at two months of age. Thirty participants (90.9%) showed a remarkable delay, comparing to typical development (cf. 2.6.3). Only three participants (9.09%) have mastered this milestone at expected age.

4.2.8.2 Hands to midline (n=44)

The following Table 4.10, demonstrates a developmental ladder of the milestone, hands to midline, mastered by 29 participants (65.90%). Fifteen (34.09%) participants have not mastered this milestone.

Table 4.10: Milestones- Hands to midline mastered (n=29)

Participants (Hand to midline)	2	1	3	4	3	2	1	2	4	3	3	1
Months	3	4	5	6	8	9	10	12	15	18	24	36



 DELAYED


In Table 4.10 the ages when this milestone was reached are shown. This developmental milestone can normally be observed at three months of age. Twenty seven participants (93.10%) showed a remarkable delay comparing to typical development (cf. 2.6.3). Two participants (6.89%) have mastered hands to midline at expected age.

4.2.8.3 Rolling (n=44)

The following Table 4.11 demonstrates a developmental ladder of the milestone, rolling, mastered by twenty nine participants (65.90%) while fifteen (34.09%) participants have not mastered this milestone.

Table 4.11: Milestones: Rolling mastered (n=29)

Participants (Rolling)	2	1	1	2	1	3	3	1	3	1	3	4	1	1	1	1
Months	5	6	7	8	9	10	12	13	15	18	20	24	26	28	36	48



 DELAYED


In Table 4.11 the ages when this milestone was mastered are shown. This developmental milestone can normally be observed at five months of age. Twenty seven participants (93.10%) showed a remarkable delay, comparing to typical development of five months, chronological age (cf. 2.6.3). Only two participants (6.89%) have mastered the milestone rolling according to typical development.

4.2.8.4 Sitting (n=44)

The following Table 4.12 demonstrates a developmental ladder of the milestone, sitting independently, mastered by twenty three participants (52.27%). Twenty one (47.72%) participants have not mastered this milestone.

Table 4.12: Milestones: Sitting independently (n=23)

Participants (Sitting independently)	1	1	3	2	5	3	2	1	3	1	1
Months	6	8	9	12	18	20	24	25	30	32	60



 DELAYED

Table 4.12 displays the ages when this milestone was mastered are shown. This developmental milestone can be observed at six months of age. Twenty two participants (95.65%) have mastered this milestone at a very late age comparing to typical development of five months, chronological age (cf. 2.6.3). One participant (4.34%) has mastered the milestone at the expected age.

4.3 VISUAL BEHAVIOUR CHARACTERISTICS; PERTAINING TO PARTICIPANTS WITH CEREBRAL PALSY

In Table 4.13 the results showed the observed characteristics that pertain to the child with CP. Table 4.13 described a number of behavioural characteristics observed during the observations that pertain to the child with CP. The characteristics behaviours seen in cerebral visual impairment (CVI) are symptoms of visual dysfunction and they in turn interfere with ongoing visual functioning to varying degrees. Each cerebral palsied child with CVI presents with a unique set of behavioural characteristics. A child with CP can present with only one characteristic or can present with various characteristics depending on the extent, time and location of injury (cf. 2.7.2.3).

Table 4.13: Unstructured observations for visual behaviour (n=57)

Unstructured observations for visual behavior		n
<u>Appearance:</u>		
1.	Does look blind	2
2.	Blank facial expressions	8
3.	Lack of visual communication skills	10
4.	Eye movements smooth, but aimless	2
<u>Vision function:</u>		
1.	Visual function varies from day to day or hour to hour	7
2.	Limited visual attention and lacks visual communication skills	11
3.	Aware of distant objects, but not able to identify	4
4.	Spontaneous visual activity has short duration	12
5.	Visual learning tiring	11
6.	Closes eyes while listening	4
7.	Balance improved with eyes closed	1
8.	Look away from people and objects	10
9.	Consistently look at either side when visual looking	12
10.	When visually reaching looks with a straight downward gaze	5
11.	Turns head to side when reaching, as if using peripheral fields	8
12.	Uses touch to identify objects	2
<u>Mobility skills:</u>		
1.	Occasionally "sees" better travelling in a car	0
2.	Difficulties with depth perception, inaccurate reach	2
3.	Unable to estimate distances	1
4.	Difficulties with spatial interpretation	5
5.	Avoids obstacles, but unable to use vision for close work	1
<u>Improved visual performances:</u>		
1.	When told "what" to look for and "where" to look	35
2.	When objects are held close to eyes when viewing	18
3.	When objects are widely spaced	27
4.	When looking at one object versus a group of objects	25
5.	When colour is used to assist in identification of objects or shapes	32
6.	When objects are against a plain background and paired with movement and sound	28

4.3.1 APPEARANCE

Facial expressions may not be perceived normal by eight participants. Ten participants appeared to have poor visual communication skills and two participants presented with aimless eye movement and two participants looked blind.

4.3.2 VISION FUNCTION

Seven participants showed variability in visual function during the course of the observations. Eleven participants showed poor visual attention and a lack of visual curiosity for communication. Four participants were able to visualise distant objects but had difficulty to identify it. Twelve participants had short durations during spontaneous visual activity. Eleven participants showed fatigue signs. Four participants avoid looking at objects by closing their eyes. One participant's head control was better with eyes closed. Ten participants overlooked their parents, guardian or toys. Twelve participants appeared to look past objects. Five participants look straight down when they attempted to reach. Eight participants looked away when reaching for objects and this may give the appearance of using their peripheral vision for reaching. Two participants have chosen to explore visual objects through touch.

4.3.3 MOBILITY SKILLS

Five participants demonstrated inaccurate movement through three-dimensional space. One participant had difficulties to estimate distances and two participants avoided obstacles in the environment although they avoided near task work. One participant was unable to estimate distance observed during reaching.

4.3.4 IMPROVED VISUAL PERFORMANCES

Participants' visual performances have improved when: being told and showed what and where to look at (35 participants). Objects were held closer to eyes when viewing (18 participants). Toys were spaced widely (27 participants). One object or toy was presented (25 participants). Colour was used to assist in identification of toys (32 participants). When toys were placed against a plain background and movement and/or sound were added (28 participants).

4.4 EYE MOVEMENTS

As described in the methodology chapter (cf. 3.4.2.5) comments and reasons for assigning a particular score to each item were recorded for 57 participants. The results of the following eye movements are shown in Table 4.14.

Table 4.14: Eye movements (n=57)

Structured observation of eye movements	n	Percentage
<u>Fixation:</u>		
1. Good, both eyes are aligned at a distance of 15cm	5	8.77
2. Loose alignment of one eye at a distance of 15cm	27	47.37
3. Brief, short	19	33.33
4. Not	5	8.77
5. Different	1	1.75
<u>Following:</u>		
1. Good, follows people, movements, looks at objects	18	31.58
2. Follows only preferential material	11	19.3
3. Follows within his own interesting space	17	29.82
4. Different:	5	8.77
5. Does not follow	6	10.53
<u>Saccades:</u>		
1. No over or undershooting is noted	0	0
2. Over or undershooting is noted when midline is crossed	12	21.05
3. Moderate movement of the head or body at any time	12	21.05
4. Large movement of the head or body at any time	16	28.07
5. Large over or undershoot is noted one or more times	17	29.82
<u>Visual response to peripheral stycarball:</u>		
1. Response to peripheral stimulation is appropriate for age	8	14.04
2. The child has a delay turning to look at the ball as it moves into range	16	28.07
3. The child's response is not equal in each eye above, below, right and left or midline	19	33.33
4. Child shown a marked field restriction	14	24.56
<u>Pupillary response:</u>		
1. There is a consensual response	51	89.47
2. Each pupil is a different size	4	7.02
3. The pupils do not get smaller	2	3.51
<u>Nystagmus:</u>		
1. No nystagmus	46	80.7
2. Fixation nystagmus	8	14.04
3. Nystagmus present	3	5.26

4.4.1.1 Fixation (n=57)

Five participants (8.77%) had good alignment with both eyes at a distance of 15 cm. Twenty seven participants (47.37%) lost the alignment of an eye while focusing on an object at a distance of 15 cm. Nineteen participants (33.33%) had focused briefly, an indication of poor focus abilities. Five participants (8.77%) were not able to focus with both eyes and one participant (1.75%) had difficulty to move the eyes voluntary (optic ataxia).

4.4.1.2 Following (n=57)

Eighteen participants (31.58%) did follow a target when it was moving. Eleven participants (19.30%) only followed preferential material. Seventeen participants (29,28%) followed in their own interesting space which is an indicator of poor pursuit. Variability during following was observed with five participants (8.77%) indicative to short visual activity. Six participants (10.53%) did not follow.

4.4.1.3 Saccades (n=57)

None of the participants could shift their gaze without over and undershooting. Twelve participants (21.05%) over or undershoot a target when the midline was crossed. Another twelve participants (21.05%) presented with moderate head and body movement when they shifted their gaze from one target to another. Sixteen participants (28.07%) had shown a marked movement of the head or body when shifting their gaze. Seventeen (29.82%) had shown a large over or undershoot at one or more times. These figures indicate that all the participants had difficulty with shifting their gaze.

4.4.1.4 Visual response to peripheral stimulus (n=57)

Eight participants (14.04%) spatial array of visual sensations were well established. Sixteen participants (28.07%) had a delay in response to detect a stimulus in the peripheral visual fields as it moves into range. Nineteen participants (33.33%) had not equal responses in each eye in all directions in their visual fields. Fourteen participants (24.56%) showed a marked field restriction. Forty nine participants

(85.96%) of the study population showed a marked delay in their visual responses to peripheral stimulus.

4.4.1.5 Pupillary response (n=57)

Fifty one participants (89.47%) had a consensual response. Differences between the pupils were noted in four participants (7.02%). No pupil constrictions or dilation were noted in two participants (3.51%).

4.4.1.6 Nystagmus (n=57)

Nystagmus was absent in forty six participants (80.70%). Eight participants (14.04%) were observed with fixation nystagmus. Nystagmus was present in three participants (5.26%).

4.5 POSTURAL ALIGNMENT IN SITTING IN THE FRONTAL PLANE

An alignment criterion was used to determine any deviations in postural alignment in sitting on a bench without a backrest or side support.

- The head aligned with the trunk, in the midline and level in the horizontal, and
- the pelvis in a neutral position; and
- the feet on the floor in alignment with the knees.

Table 4.15: Structured observation for postural alignment in sitting on a bench (n=57)

Structured observation for postural alignment in sitting on bench	n	Percentage
1. Quiet sitting position with all three criteria	0	0
2. Quiet sitting position, one criteria is missing	26	45.61
3. Quiet sitting position, two criteria is missing	5	8.77
4. Quiet sitting position, all alignment criteria is missing	26	45.61

None of the participants could sit aligned according to the criteria used for this study. One of the three mentioned criteria was missed by twenty six participants (45.61%). Five participants (8.77%) had missed two of the mentioned alignment criteria. Twenty six (45.61) had missed all alignment criteria for sitting at rest in the frontal plane as showed in Table 4.15.

4.6 THE ASSOCIATION BETWEEN EYE MOVEMENTS AND POSTURAL ALIGNMENT IN SITTING IN THE FRONTAL PLANE OF CHILDREN WITH CEREBRAL PALSY BETWEEN THE AGES OF TWO - TEN YEARS

The aim of the study was to describe eye movements and postural alignment and to investigate if there was a possible association between eye movements and postural alignment in sitting in the frontal plane of children with CP between the ages of two - ten years. The descriptive and characteristic information provide a profile of the participants who comprised of the study population. To find a correlation between eye movements and postural alignment, the correct statistical method must be identified and implemented. Both the variables, eye movements and postural alignment, are ordered categorical variables, thus a nonparametric test of association is desired. Two-way frequency tables and Spearman's rank correlation coefficient test were used to examine this association.

4.6.1 TWO-WAY FREQUENCIES TABLES

According to Ellis and Steyn (2003:51), in some cases data obtained from convenience sampling are erroneously analysed as if it were obtained by random sampling. The authors further stated that data should be considered as small population for which statistical inference and *p*-values are not relevant and instead of only reporting descriptive statistics in these cases, effect size can be determined which can be understood as a large enough difference to have an effect in practice. Although *p*-values are reported in this study more focus will be on effect sizes.

4.6.1.1 Effect size for the association in a contingency table

In many cases it is important to know whether an association between two variables are practically significant. In this study the effect size is given by Cramer's V. Guidelines to interpret Cramer's V are:

- Small effect: 0.1
- Medium effect: 0.3
- Large effect: 0.5

The two-way frequency for each variable is summarised in the tables that follow

4.6.1.1.1 The two-way frequency of postural alignment and fixation

Table 4.16: Frequencies of postural alignment and fixation (n=57)


Postural alignment	Fixation					Total
	Good				Poor	
Aligned ↓ 2 3 4 Misaligned	1	2	3	4	5	
	3 (11.54%)	21 (80.77%)	2 (7.69%)	0 (0.00%)	0 (0.00%)	26
	0 (0.00%)	0 (0.00%)	5 (100.00%)	0 (0.00%)	0 (0.00%)	5
	2 (7.69%)	6 (23.08%)	12 (46.15%)	5 (19.23%)	1 (3.85%)	26
Total	5	27	19	5	1	57

The Chi-square test has a p -value of 0.0007 indicated a significant association between fixation and postural alignment. This is confirmed with Cramer's V of 0.54 which indicate a large effect in practice.

4.6.1.1.2 The two-way frequency of postural alignment and following


The two-way frequency of postural alignment and following are shown in Table 4.17.

Table 4.17: Frequencies of postural alignment and following (n=57)

Postural alignment	Following					Total
	Good  Poor					
	1	2	3	4	5	
Aligned						
2	17 (65.38%)	5 (19.23%)	4 (15.38%)	0 (0.00%)	0 (0.00%)	26
3	0 (0.00%)	1 (20.00%)	4 (80.00%)	0 (0.00%)	0 (0.00%)	5
4	1 (3.85%)	5 (19.23%)	9 (34.62%)	5 (19.23%)	6 (23.08%)	26
Misaligned						
Total	18	11	17	5	6	57

The Chi-square test has a p -value of 0.0001 indicated a significant association between following and postural alignment. This is confirmed with Cramer’s V of 0.57 which indicate a large effect in practice.

Table 4.18: The two-way frequency of postural alignment and saccades



Postural alignment (n = 57)	Saccades					Total
	Good  Poor					
	1	2	3	4	5	
Aligned						
2	0 (0.00%)	11 (42.31%)	9 (34.62%)	5 (19.23%)	1 (3.85%)	26
3	0 (0.00%)	0 (0.00%)	0 (0.00%)	3 (60.00%)	2 (40.00%)	5
4	0 (0.00%)	1 (3.85%)	3 (11.54%)	8 (30.77%)	14 (53.85%)	26
Misaligned						
Total	0	12	12	16	17	57

The Chi-square test has a p -value of 0.0008 indicated a significant association between saccades and postural alignment. This is confirmed with Cramer's V of 0.50 which indicate a large effect in practice.

4.6.1.1.3 The two-way frequency of postural alignment and visual response to peripheral stimulus

The two-way frequency of postural alignment and visual response to peripheral stimulation are shown in Table 4.19.

Table 4.19: Frequencies of postural alignment and visual response to peripheral stimulus (n=57)


Postural alignment (n = 57)	Visual response to peripheral stimulus					Total	
	Good  Poor						
	1	2	3	4	5		
Aligned 	2	8 (30.77%)	10 (38.46%)	7 (26.92%)	1 (3.85%)	0 (0.00%)	26
	3	0 (0.00%)	1 (20.00%)	4 (80.00%)	0 (0.00%)	0 (0.00%)	5
	4	0 (0.00%)	5 (19.23%)	8 (30.77%)	13 (50.00%)	0 (0.00%)	26
Misaligned							
Total	8	16	19	14	0	57	

The Chi-square test has a p -value of 0.0011 indicated a significant association between visual response to peripheral stimulus and postural alignment. This is confirmed with Cramer's V of 0.50 which indicate a large effect in practice.

4.6.1.1.4 The two-way frequency of postural alignment and pupillary response

The two-way frequency of postural alignment and pupillary response are shown in Table 4.20.

Table 4.20: Frequencies of postural alignment and pupillary response (n=57)



Postural alignment (n = 57)	Pupillary response					Total
	Good  Poor					
	1	2	3	4	5	
Aligned ↓ 2	26 (100.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	26
3	4 (80.00%)	1 (20.00%)	0 (0.00%)	0 (0.00%)	0 (0.00%)	5
↓ 4 Misaligned	21 (80.77%)	3 (11.54%)	2 (7.69%)	0 (0.00%)	0 (0.00%)	26
Total	51	4	2	0	0	57

The Chi-square test has a *p*-value of 0.14 which is not significant between pupillary response and postural alignment. This is confirmed with Cramer’s V of 0.24 which indicate a small to medium effect in practice.

4.6.1.1.5 The two-way frequency of postural alignment and nystagmus

The two-way frequency of postural alignment and nystagmus are shown in Table 4.21.

Table 4.21: Frequencies of postural alignment and nystagmus (n=57)

Postural alignment (n = 57)	Nystagmus			Total
	Absent 	Present		
Aligned  2 3 4 Misaligned	1	2	3	
	22 (84.62%)	4 (15.38%)	0 (0.00%)	26
	4 (80.00%)	1 (20.00%)	0 (0.00%)	5
	20 (76.92%)	3 (11.54%)	3 (11.54%)	26
Total	46	8	3	57

The Chi-square test has a p -value of 0.41 which is not significant between nystagmus and postural alignment. This is confirmed with Cramer's V of 0.19 which indicate a small (unimportant) effect in practice.

4.6.2 SPEARMAN CORRELATION COEFFICIENT

Because data obtained from this investigation was ordinal, Spearman rank order correlation coefficient could also be calculated for each eye movement with postural alignment to examine this association further. In the case of correlation, the correlation is a measure of the strength of the association and the following guidelines for the interpretation is given:

- $r = 0.1$ small effect
- $r = 0.3$ medium effect
- $r = 0.5$ large effect that is important in practice (Steyn 2009).

Table 4.22: The Spearman correlation coefficients (n=57)

Variable	Postural Alignment
Fixation	0.55402
Following	0.70498
Saccades	0.64555
Visual response to peripheral	0.60585
Pupillary response	0.30094
Nystagmus	0.11461

The marked (red) Spearman Rank Order correlations are significant at a significant level of 5%. A significant association between fixation, following, saccades and visual responses to peripheral stimulus show a strong association with postural alignment. Pupillary response's correlation is also significant, but this correlation might not be as important in practice. There is no significant correlation between nystagmus and postural alignment.

4.7 CHAPTER SUMMARY

Chapter 4 listed the results obtained in this study. The data collected during this study was divided into four sections; the characteristics of the study population, description of eye movements and postural alignment in sitting in the frontal plane and establishing the association between eye movements and postural alignment in sitting in children with CP. Results were summarised in terms of frequencies, percentages, means and standard deviations. The interpretation and discussion of the results listed in this chapter will be discussed in Chapter 5.

CHAPTER 5

DISCUSSION OF RESULTS

5.1 INTRODUCTION

The previous chapter presented the results of this study. The results that were tabulated and represented in figures were divided into four sections; the characteristics of the study population, description of eye movements and postural alignment in sitting in the frontal plane as well as establishing the association between eye movements and postural alignment in sitting of children with CP. In this chapter the results obtained are discussed and interpreted with the appropriate literature. The discussion follows the same editorial sequence as in Chapter 4.

The motivation behind this study was to describe eye movements and postural alignment and to investigate if there was a possible association between eye movements and postural alignment in sitting in the frontal plane of children with CP between the ages of two and ten years. Outcome measures were needed to determine if an association exists. This will provide useful means of evaluating certain aspects of the current detection and treatment principles in children with CP. An observed clinical reasoning approach was followed and the processes followed in finding answers were based on the available literature. This study was exploratory in nature, as it sought to identify and describe the variables and to find a possible association between them.

5.2 CHARACTERISTICS OF CHILDREN WITH CP

The characteristics of children with CP were interpreted with a great deal of caution. However, closer inspection of the convenience sample reveals a minimal source of bias. The demographic details were limited in some cases due to children not residing to their birth parents and/or not having reports available.

5.2.1 AGE GROUP

The sample consisted of fifty seven participants, both boys and girls, between the ages of two and ten years. Two (3.50%) participants did not report their age. Over half of the participants (54.38%) were six years and younger and the mean age of the participants was 5.38 years (standard deviation 2.26). Children with disability or a developmental delay who require assessment or therapy are usually taken to the local clinic or the nearest public hospital if the family has no medical aid cover. Health care in the public sector, which include rehabilitation has been free for children under six years of age (Saloojee 2006:122).

The transition from infancy to early childhood occurs around two years of age (Dodd & Greaves 2010:96) (cf. 3.3.1). The age norm between two and ten years provided a continuum of motor and visual processing involvement for analysis (cf. 3.3.1). Although not the focus of this study, it has been shown that eye movement at preschool age (between two and six years) is an important determinant of later reading ability and associated academic performance (Scheiman 1997:111, Trief & Shaw 2009:29).

5.2.2 CLASSIFICATION

Cerebral palsy is diagnosed clinically, based on the presence of delays in motor development and distinct abnormalities of the neurological examination (Damiano 2007:16).

The results in Table 4.2 demonstrated that twenty four participants (42.10%) had presented with a mixed presentation of CP (cf. 2.3.3). Twelve participants had spastic diplegia (21.05%), eight participants (14.03%) had spastic hemiplegia, six participants (10.52%) had spastic quadriplegia, three participants (5.26%) had dystonia and three participants (5.26%) were diagnosed with athetosis, while one participant (1.75%) had ataxia. The age groups contained children with a variety of movement disorders. Previous studies conducted by ophthalmologists have used medical equipment to compare eye defects according to specific classifications of CP (Dutton 2008; Fazzi *et al.* 2010:194; Geddie *et al.* 2013:178; Ghasia *et al.* 2008:578; Saavedra *et al.* 2010:13), whereas the approach taken by this study was one of using structured and unstructured observation skills to determine the functional vision of

the participants and their subsequent motor abilities and actions. The aim of this study was to avoid excluding any individuals according to their particular classification of CP, which can be considered a form of bias.

This study emphasised the fact that the clinical presentation of the subtypes does vary across countries and that the classification systems will differ depending on the characteristic(s) chosen as the basis for classification, with no single approach emerging as definite (Rosenbaum *et al.* 2007:11) (cf. 2.3.3). The extent of observed tonal abnormalities as well as movement disorders and typology, determine the clinical subtype of CP. Twenty four participants (42.10%) were classified with a mixed presentation. Assigning children to a distinct clinical group is not a straightforward process. The researcher elected to assign a mixed classification to children if no predominant type – or more than one type – of tone and movement abnormalities was present. Signs also take time to develop, and it is generally agreed that the child should be at least three years before the child with CP can be classified according to the sub-classification with predominant features of tone and movement abnormalities (Krägeloh-Mann & Staudt 2010:65). Although the gross motor functional classification system (GMFCS) has been widely adopted to classify movement abilities (Dodd & Imms 2010:10; Rosenbaum *et al.* 2007:12), it was not in common use at the time of this study.

5.2.3 ACCOMPANIED IMPAIRMENTS

As per the definition of CP given earlier in this study, the condition is characterised by accompanied impairments – which applied to twenty three participants (slightly fewer than half or 40.35%) of the fifty seven participants in this case (cf. 2.3.4). The majority (82.60%) of the sample of twenty three participants presented with epilepsy, while one (4.34%) presented with a hearing impairment and three (13.04%) with a visual impairment related to the anterior segment of the eye, i.e. cataracts (dense lens), choiriditis (inflamed choroid) and retinopathy of prematurity (abnormal blood vessel growth in retina).

Hoon and Tolley (2013:435) report that approximately 40% of children with CP develop epilepsy (cf. 2.3). In this study nineteen participants (33.3%) of the fifty seven participants were diagnosed with epilepsy, which is in accordance to the literature.

One (1.75%) participant of the fifty seven participants was diagnosed with a hearing impairment. Dormans and Pelligrino (1998:86), found 3% to 10% children with CP have hearing loss, but due to the difficulty of identifying hearing problems, particular with unilateral or high-frequency hearing loss the incidence is probably higher (cf. 2.3).

By means of visual examination, three participants (5.26%) of the fifty seven participants were diagnosed with a visual impairment related to the anterior segment of the eye. Disorders of visual acuity, refraction and eye disease are commonly diagnosed amongst children with CP and treated by ophthalmologists, but as Scheiman (1999:57) states, it is unfortunate that in many cases the eye examination only includes an evaluation designed to detect these particular conditions, although as this study has shown, there are many more significant visual problems that must be considered. Significant visual defects and impairment may be overlooked due to the severity of the neuro-muscular disability caused by CP (cf. 2.7.1).

5.2.4 THERAPEUTIC INTERVENTIONS

Thirty nine participants (68.42%) have received some kind of intervention. Of the thirty nine participants twenty nine participants (74.35%) had attended therapy from all three therapeutic disciplines namely, occupational therapy, speech therapy and physiotherapy. Six participants had received either occupational (n=3) or physiotherapy therapy (n=3) intervention. At the time of the study 18 participants had not yet received any intervention and the reasons are unknown. The researcher acknowledges the value of intervention and team work. Treatment and management goals need to incorporate appropriate combinations of interventions to promote function, prevent secondary impairments and increase a child's developmental and functional capabilities. Other interventions such as surgery and botulinum injections were also amongst therapies that have been received.

Three participants (5.26%) of the 57 participants had undergone surgery for lower extremities and one participant (1.75%) of the 57 participants received botulinum injections for lower extremities. The majority of children with CP do not have musculoskeletal deformities at birth and develop over time of the combined effects of movement disorder and according to Rogers (2010:146) the musculoskeletal deformities in CP is very high. Graham (2007:22) (cf.2.3) found hip displacement to

be 35% in CP, due to hyperactive hip adductors causing scissoring of the legs (Hoon & Tolley 2013:420). Although the literature asserts that a high percentage of children with CP do undergo orthopaedic procedures for muscle shortening, joint deformities and hip dislocation due to abnormal and asymmetrical distribution of tone (Graham 2007:22; Hoon & Tolley 2013:442), this was not found to be the case amongst the participants in this study with the following explanations. When working in cross-cultural settings and in poorly resourced areas it cannot be assumed that all children with CP have access to medical examinations and interventions. Although the evidence based therapeutic intervention is not strong there is a general consensus that therapy (OT, PT, ST) can make a change to the quality of the child's performances in a functional context (Case-Smith *et al.* 2010:46). Mantovani (2007:26) states it is clear that most children with CP do not have a single cause of their condition. A series of contributing factors that interact in complex ways influence the final outcome. This confirms the importance of team work as seen in clinical practice.

5.2.5 MEDICAL EXAMINATIONS AND INVESTIGATION

According to the data presented in Table 4.5 indicated that 32 participants (56.15%) of the 57 participants had received medical examinations and or investigations. Thirteen participants (40.62%) received an eye-examination and one participant (3.12%) received a hearing examination. One participant (3.12%) received a radiology investigation for his/her hips. The neurology investigations consisted of an electroencephalogram (EEG) pattern and magnetic resonance imaging (MRI) Seven participants (21.87%) received MRI investigations and ten (31.25%) received and EEG investigation. The power of neuroimaging in revealing the cause of CP is well accepted and can define different kinds of brain pathology including various congenital malformations and different destructive lesions in white and grey matter (Flodmark 2007:18). Often a cause cannot be found in the history of children with clear clinical evidence of CP (Rosenbaum 2003:970).

Although 13 participants received visual examination only three participants were diagnosed with visual defects as explained in the previous paragraph (cf. 5.2.3). It is assumed that ten participants had no visual defects or impairment. These results are a concern as they contradict the literature. Fazzi *et al.* 2010:194) state that “*Visual disorders are a main symptom in the clinical picture of CP and there is currently*

strong evidence that they are not just associated disorders but rather on a par with motor disorders". Visual impairment, an accompanied disturbance in children with CP can include peripheral problems, such as ocular disorders, central problems that cover the spectrum of cerebral visual impairment and oculomotor dysfunction as well as visual-cognitive dysfunction (Erhardt 1990:1; Geddie *et al.* 2013:176; Ghasia *et al.* 2008:572; Scheiman 2002). It is also confirmed by Fazzi *et al.* (2010:203) that the clinical picture of the main forms of CP (diplegia, hemiplegia and quadriplegia) can be defined not only by specific patterns but also by specific neuro-ophthalmology profiles that include peripheral problems such as ocular disorders (refractive errors, fundus oculi abnormalities), central problems that cover the spectrum of cerebral visual impairment (CVI), reduction in acuity, contrast sensitivity, visual fields and oculomotor dysfunctions. The spectrum of visual impairments including the difficulty to move and control the eyes are extremely broad (Dutton 2008) (cf. 2.7).

The researcher acknowledge a study done by Ghasia *et al.* (2008:572), which recorded the frequency and severity of visual sensory and motor deficits in children with CP. Ghasia *et al.* (2008:572) further state that it is difficult even for skilled examiners to categorise and describe accurately the spectrum of visual defects in children with CP and this explains why there are so few reports to record the frequency and severity of visual and sensory motor deficits in children with CP. The examinations are labor intensive and time consuming requiring repetitive observations with subjects who maybe cannot operate, supplemented by eye movement recordings, tedious perimeter, and when necessary, visual evoked potential (VEP) measures of acuity (Ghasia *et al.* 2008:572).

This investigation made this study extremely challenging from a clinical perspective. Research of the nature explored in this study is complex because the issues surrounding the inabilities of children with CP are always multidimensional and multifaceted. These issues include the reality that most 'outcomes' are multi-determined, and that the developing child with CP represents a constantly moving and changing body challenged by an ever changing environment. This becomes even more difficult when working in cross-cultural settings and in poor communities. This means that medical equipment is not always available to assess the visual system, as seen during outreach interventions with children with CP. The OT's observation skills and clinical reasoning are important to determine the child's occupational

profile of what the child can achieve and how; what the child nearly do and what is interfering with the child's functional abilities.

To be able to take part in an activity both the motor and eye movement behaviours are depended on the quantity, quality and variability of the movement, that are challenged by an environment (Capelovitch 2012). When building up visual information in the brain and to be able to learn a skill, the child needs eyes, freedom of movement with stability, pathways and interconnected structures without obstructions within a supportive environment (Stolk *et al.* 2009:31). Occupational therapists therefore need to detect and understand both motor and visual impairments and acknowledge that although it is difficult to assess eye movements, the visual function is an integral and inseparable component of the body's motor system. The two parts form a holistic whole, with the visual function serving as the foundation of a child's early physical, mental and emotional development. Children with CP lack variability, quality, and quantity motor and eye movement behaviours that influence participation (Stolk *et al.* 2008; Capelovitch 2012).

5.2.6 MEDICATION

The results showed in Table 4.6 indicated that 30 (52.63%) participants had used prescribed medication. Twenty nine participants (96.66%) received anti-convulsion therapy. Hoon and Tolley (2013:435) report that approximately 40% of children with CP develop epilepsy (cf. 2.3).

However, these results do not correspond with Table 4.3 which indicated that 19 participants were diagnosed with epilepsy. A possible explanation can be that eleven participants' epilepsy was under control and parents or guardians did not find it necessary to report it or it could be the way the question was phrased. One participant (3.33%) received Ritalin.

5.2.7 UNSTRUCTURED OBSERVATION FOR EYE CONTACT, HEAD CONTROL AND UPPER-EXTREMITY USE.

Eye contact, head control and upper-extremity use will be discussed separately. The participants were observed whilst engaged in play with the parent or guardian. It was

important for the researcher to observe how the participant reacted motorically and visually within the social and physical environment in the most stable supportive position (Myers *et al.* 2010:685) (cf. 3.4.2.3).

The results will be interesting from a clinical perspective as children who lack sufficient postural control to maintain a stable position benefit from adaptive positioning (Shepherd 2010:491). According to De Graaf-Peters *et al.* (2007:1193) the presence of support can alter postural activity.

5.2.7.1 Eye contact

Vision may serve as a motivator for children to explore interesting sights and engage with people by visual focussing on their eyes to facilitate emotional attachments and communication (Schneck 2010:380).

The results in Table 4.7 showed twenty nine participants (50.88%) made eye contact, twenty three participants (40.35%) made brief eye contact and five participants (8.77%) did not make eye contact in a *stable supportive position*.

The results indicated that twenty eight participants (49.12%) did not master sustained eye contact, a skill that can be observed in very young infants. Infants as young as 60 hours old are able to orient themselves towards a visual stimulation and about 6-8 weeks give real smiles with eye contact (Atkinson 2002:63; Shumway-Cook & Woollacott 2012:202) (cf. 2.6.5). The absence of eye and/or brief contact observed can be argued or explained from different angles.

Children with CP present with a unique set of visual and motor behavioural characteristics pending on the lesions, extent and timing of the brain injury (Fazzi *et al.* 2010:194). Fazzi *et al.* (2010:195) state that there is enough evidence that visual disorders peripheral and/or central (cerebral visual impairment) fall very much within the spectrum of CP comorbidity that in particular can be linked to the involvement of the posterior visual pathways and of the oculomotor control systems. Roman-Lantzy (2007:2/15) states that cerebral palsied children have an unique set of visual behaviours and are characterised with poor visual attention, lack of visual curiosity of the human face and or turning the head to the side as if using the peripheral vision. If the child with CP continuously uses the visual behaviours it may

cause atypical postures. In clinical practice, the researcher has observed that supporting a child with CP in a stable supportive position does not necessarily enable meaningful functional vision to discriminate ‘what’ the person sees and ‘where’ to look at.

5.2.7.2 Head control

According to Table 4.7 it also shows that thirty participants’ (52.63%) head control was good in all planes with the most stable supportive position, eighteen participants (31.58%) needed some kind of assistance to keep the head up and nine participants (15.78%) could not maintain midline and present with an asymmetry to the left or right. This showed that the ability to control one’s body position in space emerges from a complex interaction of musculoskeletal and neural systems referred to as postural control (Shumway-Cook & Woollacott 2012:161). Many factors contribute to postural control and include: body alignment which minimizes the effect of gravitational forces, muscle tone, postural tone and inputs from the sensory systems that provide a frame of reference for postural control (O’Brien & Williams 2010:254).

Pathology in the central nervous system (CNS) impairs the coordination of posture and movement due to disordered muscle tone that results into stereotyped movement patterns, producing atypical interactions with other bodily systems, affecting the ability to process sensory information (Bierman *et al.* 2013:18) (cf. 2.4). On the other hand the inability to move and coordinate both eyes may result in compensatory head tilts to overcome double vision (Goldberg *et al.* 1991:667). Visual behavioural characteristics can also be compensatory in nature, developing in response to a child’s preferred visual field and resulting in a particular head tilt or thrust (Scheimann 2002). Such head positioning should not automatically be attributed to postural tone, since it may be used by the child as a means to control focus on his or her particular field of vision (Ghasia *et al.* 2008:578).

Head movements directly influences visual acuity and according to Saavedra *et al.* (2010:20), children with CP may work harder than their peers to stabilise their vision for academics and it is suggested that an ophthalmologist need to confirm visual acuity with head free testing to account for the contribution of postural control to acuity in children with mild to moderate CP.

5.2.7.3 Upper-extremity use

The results showed the use of upper extremity and grasp. In Figure 4.7 twenty nine participants (50.88%) could reach with a grasp. Nine participants (15.78%) did not grasp with a reach although objects were offered and nineteen participants (33.33%) had no adequate hand function to grasp. These results require analysis of the dynamic relationship between the task, individual and the environment. These results were not unexpected as children with CP move with effort. Children with CP also have uncontrolled motor behaviours that may restrict participation (Hadders-Algra 2000:712) (cf. 2.6.3).

Difficulties and complexity of both/either the postural control and visual processing, may interfere with the reach and grasp. Visual inattention and very distinct field preferences may result in mal-alignment of the posture as the child with CP will only reach and grasp in his preferred visual fields causing an asymmetry in the body segments and eye alignment (Roman Lantzy 2007:3/2). The damaged pathways may cause difficulties to look and to touch simultaneously (Dutton 2008) as observed in practice. Two distinct components that appear to be controlled by different neural mechanisms (Shumway-Cook & Woollacott 2012:501) (cf. 2.6.3) as well as the two visual pathways, the dorsal and ventral streams are involved in reach and grasp (cf. 2.7).

Before a child reaches, from a kinematic perspective, the coordination in reaching for eye-hand coordination is characterised by the sequential activation of eye, head and then hand movements (Shumway-Cook & Woollacott 2012:480). Eye movements alone are used to locate an object in our central visual field, or the eyes and head when the target is in the peripheral visual field, to be able to reach, grasp and manipulate (Shumway-Cook & Woollacott 2012:480).

The relation between posture (head control), movement (reach with grasp) and vision (eye contact) is clearly evident according to Table 4.7 where it can be seen that the number of children who scored well in eye contact also scored well with head control and reach and grasp. Conversely, children with poor eye contact with poor head control had difficulty with reach and grasp. These results showed, without statistically evidence, a remarkable association between posture and eye movements observed through play (Myers *et al.* 2010:681).

5.2.7.4 Milestones

Motor milestones are age-appropriate behaviours with definable onset arising from on-going interactions of the neural, body and motor systems adapting to the influence of the physical laws of the environment (Howle 2005:16; Foley & Greaves 2010:74) (cf. 2.5). Typical development is used in this study as a guide to compile the criteria for observations.

In this study, where milestones were obtained from parents, thirteen guardians (22.80%), did not complete this section as the information was unknown to the guardian and this means that forty four (77.19%) of completed questionnaires were available for analysis.

According to Figure 4.1 the majority of the children had mastered eye contact (97.7%) and hand regard (75.00%). Almost two thirds (65.9%) of the children had mastered hands to midline (65.90%) as well as rolling (65.90%) whilst only half of the children (52.27%) sat independently. These figures indicated that children with CP have significant motor delays and is not unexpected, confirmed by the literature (cf. 2.5).

5.2.7.4.1 Eye contact

Table 4.8 demonstrated the milestone, eye contact, mastered by forty three (97.72%) participants. One participant (2.27%) has not mastered this milestone. The possible reasons for a delay or absence were already discussed (cf. 5.2.7.1).

Fifteen participants (34.88%) had mastered this milestone at expected age and twenty eight (65.11%) participants had mastered eye contact at a very late stage. A common remark made by the parent or guardian was that their children did not consistently make eye contact and rather preferred to gaze at lights. This behaviour is a striking feature of children with CP (Roman-Lantzy 2007:3/1). A number of children with CP appear overly attentive to lights and room lights may have to be reduced for function.

5.2.7.4.2 Hand regard

Table 4.9 demonstrated hand regard, mastered by thirty three (75.00%) participants and not mastered by eleven participants (25.00%). Comparing hand regard to typical development a significant delay is shown. Three participants (9.09%) have mastered hand regard at expected age. Thirty participants (90.90%) showed a marked developmental delay as they have reached this milestone between three and 48 months (cf. 2.6.3). The researcher has discussed upper-extremity use in a previous section (cf. 5.2.7.3).

5.2.7.4.3 Hands to midline

The results in Table 4.10 demonstrated hands to midline, mastered by twenty nine participants (65.90%) and not mastered by fifteen participants (34.09%). Comparing hands to midline to typical development a significant delay is shown. Only two participants' (6.89%) hands to midline were age appropriate and twenty seven participants (93.10%) showed a remarkable delay. At the end of the first trimester the infant has established midline and can maintain the head and hands in midline (Boehme 1988:45) (cf. 2.6.3). Clinically, the asymmetrical use of upper extremities do correlate with the presence of preferred visual fields and with atypical postural tone and movements seen in CP children (Jacobson & Flodmark 2010:27) (cf. 2.4).

5.2.7.4.4 Rolling

The results in Table 4.11 obtained from the parent or guardian indicated twenty nine participants (65.90%) had mastered rolling and not mastered by fifteen participants (34.09%).

Two participants (6.89%) mastered rolling at expected age. Twenty seven participants (93.10%) reached this milestone between six and 48 months indicating a remarkable developmental delay (cf. 2.6.3). Functional vision is a dynamic interactive process for the organisation of space, balance, posture, movement and learning (Dutton 2008:36). One of the primary goals of postural control is to stabilise the head in space and it is in the head where the sensory organs for visual and vestibular systems are embedded making refined head control of critical importance for both orientation and balance (Saavedra *et al.* 2010:13) as seen in rolling.

The implication for OTs during treatment is to use toys to facilitate rolling while the infant fixates on a toy, using vision as a motivator. Careful observations are necessary to observe eye movements during head and body movements. During head movements in any direction, the semicircular canals of the vestibular labyrinth signal how fast the head is rotating and the oculomotor system responds to this signal by rotating the eyes at an equal and opposite velocity to keep the visual image on the retina and any deviations of eye control will influence this process (Goldberg *et al.* 1991:669). Evidence exists that children with CP may have vestibular hypofunction as demonstrated during posturography causing instability and frequent falls in children with CP (Saavedra *et al.* 2010:20).

This explains why an OT cannot separate the sensory systems from the motor systems during intervention. Rolling demands the use of several different systems in the body, and the condition CP causes these systems to ‘compete’ to process information simultaneously. Therapy must therefore channel the demands by separating these systems during intervention for processing and adapting the environment to prevent clutter (Dutton 2008:36).

5.2.7.4.5 Sitting

Table 4.12 demonstrated sitting independently, mastered by 23 (52.27%) participants and not mastered by 21 (47.72%) participants. One participant (4.34%) mastered sitting at six months (cf. 2.6.3). Twenty two participants (95.65%) had reached this milestone between eight and 60 months indicating a remarkable developmental delay (cf. 2.6.3). It is stated by De Graaf-Peters *et al.* (2007:1195) that if children with CP do not achieve sitting independently by the age of 18 months they will be hampered by serious dysfunction of the basic level of postural control. According to this statement 33 (75.00%) participants could be hampered by serious dysfunction of postural control influencing all goal directed activities. As different systems contribute to sitting it is important in practice to determine what interferes with the inability to sit.

In combining the postural control and visual processing in clinical practice consideration must be given to the dynamic interactions between the systems. Often OTs concentrate on the motor development but according to this study the importance of how a child uses the visual processing system in combination with the

postural system cannot be over emphasised enough taking into account the task and the child that is accompanied with a myriad of factors that influence participation. The use of vision has an impact on all areas of development (Trief & Shaw 2009:21).

5.2.8 VISUAL BEHAVIOUR CHARACTERISTICS

The results in Table 4.13 confirmed what is known regarding CVI in children with CP (cf. 2.7). The results showed typical behavioural traits (Roman-Lantzy 2007:2/12). In clinical practice it is necessary to realise the impact these characteristics may have on participation. Movement disorders in children with CP are well described; however, children with CP also experience the world differently through the affected visual processing system. To these children this is their reality and may show specific characteristics.

A checklist (Appleby 2005:34) was used to observe characteristics related to CVI in children with CP and consisted of appearance, visual dysfunction, mobility skills and improved visual performances (cf. 4.3). The results showed that a child with CP can present with a unique set of behavioural characteristics, such as only one characteristic or with various characteristics depending on the extent, time and location of injury (cf. 2.7). This means that OTs need to realise what impact these characteristics will have on the child's alignment for participation.

The results according to Table 4.13 also indicated that the majority of participants had improved residual vision for performances by structuring the environment, reducing the clutter, providing clues to connect to information, looking as directed, shortening the viewing distance and using contrast and or colour (Stolk *et al.* 2009:45) (cf. 4.3). These results indicated the importance of how the OT needs to present an activity for a child with CP and stresses the importance for adaptations in the environment for optimal functional vision to support the postural alignment and control (Dutton 2008:35; Scheiman 1997:219).

5.2.9 EYE MOVEMENTS

With regard to eye movements, the key findings were that eye movement disorders are an important diagnostic and management concern because of the effect such problems have on the functional capabilities of an individual and that the function of

eye movements goes well beyond vision and reflects higher central processing. The four main eye movements under investigation will be discussed.

5.2.9.1 Fixation

Table 4.14 demonstrated fixation. Five participants (8.77%) had good alignment with both eyes. Twenty seven participants (47.36%) lost the alignment of an eye while focusing on an object. Nineteen (33.33%) participants focused briefly. Five participants (8.77%) were not able to focus with both eyes and one participant (1.75%) had difficulty to move the eyes voluntary for focus. These results indicated that the majority of participants (91.22%) have difficulties to keep both foveas simultaneously on a target for binocular vision to take place (Scheiman 1997:77) (cf. 2.5). Except for the very young child, all children should be able to sustain precise fixation with no observable movement of the eyes for 10 seconds (Scheiman 1997:85; Scheiman 2002:3). This requires an analysis to determine if fixation relates to posture and/or other higher central processing systems.

Variable eye misalignments can be seen in early infancy but these misalignments should diminish over time with the eyes become absolutely straight at three months of age to receive one single impression of the world (Geddie *et al.* 2013:174). For binocular fusion to occur the two eyes must be aligned on the object of regard, called motor fusion, it requires coordination of the six extraocular muscles of each eye and the optics, or refractive error, of the two eyes must be approximately equal (Scheiman 1999:67; Scheiman 2002:5; Schneck 2010:375). Problems with either alignment or refractive equality will cause binocular vision disorders (Scheiman 1999:68).

Optimal visual information processing depends on fixation (Scheiman 1997:85), and the maintenance of a vertical posture of head and trunk against the forces of gravity (Hadders-Algra 2010:1829) (cf. 2.3). Fixation is task dependent and may vary within a familiar or unfamiliar environment while difficulties in orientation are mostly seen in an unfamiliar environment (Stolk *et al.* 2008; Brien & Williams 2010:254). Children with CP may present with inadequate fixation, unable to keep their focus on an object in a crowded environment, they have visual inattention and a tendency to look away from objects being offered (Stolk *et al.* 2009:33; Scheiman 1997:85) (cf. 2.8).

From the above discussion it is evident that multiple reasons may influence eye and postural alignment. It is suggested by Saavedra *et al.* (2010:21) that the training of visual motor skills, specifically fixation may improve head stability and thus, improve the control of posture.

Table 4.16 indicated a significant association between fixation and postural alignment confirmed by Cramer's V of 0.54 which could have large implications for the way therapists will assess, prioritise aims and provide treatment in clinical practice (Ellis & Steyn 2003:51). It was found that the participants who scored two (one criteria missing) for postural alignment also scored two (loose alignment of one eye) for fixation (**80.77%**) which is indicative of minimal deviations of both fixation and postural alignment.

On the other hand, the table also demonstrated that participants who scored a three (brief and short) for fixation scored a four (all alignment criteria missing) for postural alignment (**46.15%**), which indicated, according to the ordinal ordered categorical variables, that participants with the most deviated alignment of posture in sitting had poor fixation abilities.

This is in accordance to a study of children with CP done by Ghasia *et al.* (2008:575) which indicated that each child's GMFCS level correlated with the visual deficits with which the child presented. Children with the least amount of functional mobility, Level 5, were at greatest risk for visual deficits and children who scored a level 1 (mild) visual deficits was rare or absent.

5.2.9.2 Following/Tracking

Table 4.14 demonstrated following or tracking. Eighteen participants (31.58%) did follow a target when it was moving. Eleven of participants (19.3%) only followed preferential material. Seventeen (29.82%) followed in their own interesting space. Variability during following was observed with five participants (8.77%) indicative to short visual activity. Six participants (10.53%) did not follow. These results indicated that 39 participants (68.42%) between the ages of two and ten years have significant difficulty to continuously keep the foveal fixation on moveable objects in space. The infant has the ability to smoothly track circularly with both eyes at six months (cf. 2.7). These results indicated that the child with CP has eye movement

difficulties (Erhardt 1999:125). Tracking occurs when a person follows a moveable target as well as when a person moves into the optic flow. Different systems are involved at the brainstem level and visual cortex V5 (Riordan-Eva & Hoyt 1999:247) (cf. 2.5).

To be able to smooth track a stable base of support is needed with an aligned posture for postural stability and orientation, as well as a degree of mobility to move within the base of support. Due to damage in the dorsal and ventral pathways children with CP have difficulties to track when an object itself presents a complex display or when an object is viewed within an environment that presents a complex display, as well as when an object is viewed at the same time that other sensory or motor input is competing for attention (Roman-Lantzy 2007:1/12; Hyvärinen 2004). Therefore the visual background and objects need to be monitored as well as the sequences of muscle synergistic activation for postural control and alignment.

Table 4.17 indicated a significant association between following and postural alignment confirmed with Cramer's V of 0.57 which could have large implications for the way therapists will assess, prioritise aims and provide treatment in clinical practice (Ellis & Steyn 2003:51). When the association between postural alignment and following was examined it was found that participants who scored two (one criteria missing) for postural alignment scored one for good following (**65.38%**), which is indicative of minimal deviations of both following and postural alignment.

On the other hand, Table 4.17 also demonstrated that participants who scored a five for following (do not follow), scored a four (all alignment criteria missing) for postural alignment, (**23.08%**), which indicates according to the ordinal ordered categorical variables, that participants with the most deviated alignment of posture in sitting, had absent following.

5.2.9.3 Saccades

Table 4.14 demonstrated saccades/shifting of eye movements. Saccadic or scanning is the fastest eye movements and are defined as a rapid change of fixation from one point in the visual field to another (Schneck 2010:375). According to Table 4.14 all participants had difficulties shifting their eyes accurately indicating that children with CP have significant dysfunction with gaze shifting. These results are

concerning. Twelve participants (21.05%) over or undershoot a target when crossing the midline. Another 12 participants (21.05%) presented with moderate head and body movement when shifting their gaze from one target to another. Sixteen participants (28.07%) showed a marked movement of the head or body when shifting their gaze. Seventeen (29.82%) showed a large over or undershoot at one or more times.

The infant at six months has the ability to accurately shift the eyes between targets in different focal lengths without moving the head and movement during adaptive interaction of eye-hand goal directed activities if the target is in the central field (Erhardt 1990:57). The generation of a saccade involves a pulse of increased innervation to move the eye in the required direction and a step to maintain a new position in the orbit by counteracting the visco-elastic forces working to return the eye to the primary position (Riordan-Eva & Hoyt 1999:270) (cf. 2.7). Children with CP who presented with gaze dysfunction will use horizontal or vertical head thrusts to facilitate gaze shifting (Ghasia *et al.* 2008:578). The researcher has observed in practice if the body and head compensate for the lack of saccades by thrusting backwards or sideways it limits the variety of movements of the body and head, resulting in stereotypical movements causing secondary complications such as deformities and mal-alignment in posture. A child with CP will use compensatory strategies such as thrusting the body backwards to gain visual information as seen in the practice setting. Both, the atypical tone and the inability to shift the eyes may cause eye and posture movement disorders resulting in a mal-alignment posture (Dutton 2008:9; Hyvärinen 2004:2/5).

Table 4.18 indicated a significant association between saccades and postural alignment confirmed with Cramer's V of 0.50 which could have large implications for the way therapists will assess, prioritise aims and provide treatment in clinical practice (Ellis & Steyn 2003:51). Analysis of the data confirmed the positive association between the levels of deviation made to postural alignment and saccades which indicate a large effect in practice as shown in Table 4.18. When the association between postural alignment and saccades was examined it was found that the participants who scored two (one criteria missing) for postural alignment also scored two (over or undershooting) for saccades (**42.31%**) which is indicative of minimal deviations for both saccades and postural alignment.

On the other hand, the participants who scored a five (large under or overshoot) for saccades scored a four (all alignment criteria missing) for postural alignment (53.85%). This indicates, according to the ordinal ordered categorical variables, that participants with the most deviated alignment of posture in sitting, had large over or undershoots during saccades.

5.2.9.4 Visual response to peripheral stimulus

Table 4.14 demonstrated responses to peripheral stimulus. Eight (14.03%) participants spatial array of visual sensations available for observation were well established. Sixteen (28.07%) participants had a delay in response to detect a stimulus in the peripheral visual fields. Nineteen (33.33%) participants did not have equal responses in each eye in all directions in their visual fields. Fourteen (24.56%) participants showed a marked field restriction. These results indicated that forty nine (85.96%) participants with CP have significant difficulty to respond to peripheral stimulus.

Table 4.19 indicated a significant association between visual response to peripheral stimulus and postural alignment confirmed with Cramer's V of 0.50 which could have large implications for the way therapists will assess, prioritise aims and provide treatment in clinical practice (Ellis & Steyn 2003:51).

The data confirmed the positive association between the levels of deviation made of postural alignment and response to peripheral stimulus which indicates a large effect in practice. The infant has the ability at twelve months to locate objects peripherally (Moller 1997:54) (cf. 2.7). Children may have delayed responses in looking at objects or an unusual field location is present (visual field preference) in addition to visual field impairments (Roman-Lantzy 2007:3/1) whilst on the other hand Hadders-Algra (2000:712) says that children with CP have restricted limited movements and are unable to adapt to specific conditions demanded by the task. This requires analyses of the dynamic relationship between the ability to maintain a relationship between the body segments and between the body and the environment for locating objects in the periphery.

Table 4.19 showed when the association between postural alignment and visual response to peripheral stimulus was examined it was found that the participants who

scored two (one criteria missing) for postural alignment scored a one (appropriate response) for visual response to peripheral stimulus (**30.77%**).

On the other hand, participants who scored a four (response is not equal to each eye) for visual response to peripheral stimulus scored a four for postural alignment (**50.00%**). This indicated, according to the ordinal ordered categorical variables that participants with the most deviated alignment of posture in sitting, had responses to peripheral stimulus which were not equal in each eye above, below, right and left of the midline.

5.2.9.5 Pupillary response

Table 4.14 demonstrated pupillary response. Fifty one participants (89.47%) had a consensual response. Differences between the pupils were noted in four participants (7.02%) and no pupil constrictions or dilation was noted in two participants (3.51%).

According to the literature the consensual and direct pupillary light reaction develops at the same time and is present by 31 weeks gestation (van Hof-van Duin & Mohn 1984:79) (cf. 2.7). Atkinson (2000:21) states, failure of pupil constriction in one or both eyes is likely to indicate severe neurological problems. These results are in accordance of the observation made of two participants who 'looked blind' as shown in Table 4.13.

Table 4.20 indicated no significant association between pupillary response and postural alignment confirmed with Cramer's V of 0.24. The data depicted in Table 4.19 showed no significance between pupillary response and postural alignment as expected as the observation was elicited by a light. The main purpose was to observe the presence of any severe neurological problems (Riordin-Eva & Hoyt 1999:244).

5.2.9.6 Nystagmus

Table 4.14 demonstrated nystagmus. Nystagmus was absent in forty six participants (80.70%). Eight of the participants (14.04%) were observed with fixation nystagmus. Nystagmus was present in three participants (5.26%).

The data depicted in Table 4.21 showed no significance between nystagmus and postural alignment which indicate a small (unimportant) effect in practice. According to the data one participant presented with ataxia. A child with ataxia not only presents with bodily incoordinations but also presents with jerky, uncontrolled eye movements (Hoon & Tolley 2013:440; Black 1982:47).

By 1-4 months of age a child had developed the ability to fixate on objects and any interruption of the development results in nystagmus (Geddie *et al.* 2013:179). Reduced visual acuity is caused by an inability to maintain steady fixation or so called fixation nystagmus (Riordan-Eva & Hoyt 1999:276). Geddie *et al.* (2013:179) state that a small optic nerve, an underdeveloped fovea, a variety of rods or cone abnormalities can result in nystagmus. Diseases of the labyrinth and its central connection lesions of the cerebellum cause disorders in the control of eye movements (Ghez 1991:634).

5.2.10 POSTURAL ALIGNMENT

Table 4.15 demonstrated postural alignment in sitting in the frontal plane. An alignment criterion was used to determine any postural alignment deviations in sitting (cf. 4.5).

The results shown in Table 4.15 showed that none of the participants met the criteria for sitting on a bench without support. This means that all participants deviated from the required postural alignment criterion (head in midline with trunk, pelvis legs and feet).

Twenty six participants (45.61%) had missed one criterion in sitting. This indicated that the child with CP may have the adequate range of movement, postural stability and orientations to be able to maintain the sitting posture in an upright position with minimal deviation.

Five participants (8.77%) had missed two of the mentioned alignment criteria indicating less coordinated patterns of muscle synergies that influence the ability to maintain a relationship between the body segments (biomechanical alignment of the body) and between the body and the environment (orientation of the body to the environment) for a task (Shumway-Cook & Woollacott 2001:164).

According to the results another twenty six participants (45.61%) had missed all alignment criteria for sitting at rest, in the frontal plane. This indicated that these participants are more severely involved, causing little or no movement with possible contracture towards mid-position in the limbs and patterns of movement may be persistent with asymmetry (Hadders-Algra 2010:1823) compared to the typically developed infant who has the ability to sit independently with legs in line with the trunk at nine months (Bly 1994:173) (cf. 2.6.3).

The OT relies on basic theory and skills for clinical reasoning in order to drive decision making, in an area of speciality such as Pediatric-Neurology with its complexities and multiple dimensions. A child with a marked asymmetry whose head is always turned to the one side due to high postural tone and/or preferred visual fields will result in incorrect synergetic muscle activity in the body and eye(s) (Baker-Nobles 2011:3). It was anticipated that the eye movements, fixation, following saccades and response to peripheral stimulus would correlate with the postural alignment.

5.2.11 THE SPEARMAN CORRELATION COEFFICIENT

As data obtained from this investigation was ordinal, Spearman rank order correlation coefficient could also be used to calculate for each eye movement with postural alignment, to examine this association further. Correlation is a measure of the strength of the association (Ellis & Steyn 2003:51).

The results in Table 4.22 confirmed a significant (significant level of 5%) association between fixation, following, saccades and response to peripheral stimulus and postural alignment. Association of pupillary response is also significant but this association might not be as important in practice. There was no association between nystagmus and postural alignment.

Although fixation, following, saccades and visual response to peripheral show a strong association with postural alignment it is important in practice but does not necessarily mean that there is a causal relationship. It can also not be assumed that improving visual abilities will mean the improvement of postural alignment and vice versa.

5.3 CHAPTER SUMMARY

In this chapter the results were discussed. An infant's functional visual system is fully developed by as early as six months of age, before other functions such as the ability to walk and talk, which points to the visual function being the necessary precursor to the proper development of other bodily functions. As such, eye movement should not be disregarded and separated from posture with other functions in the therapy process. The various different functions performed by the brain must be approached holistically.

The study has brought the clinical expertise and literature together to describe the difficulties the child with CP experiences. The information presented may assist an OT to observe the child with CP with various motor movements and visual behaviours, recognise and understand the impairments that constrains postural alignment and functional vision, which include eye movements for – communication, orientation and mobility, sustained visual tasks and activities of daily living that are present in all cultures and at all ages. This will enable the OT to determine the child's functional performances or occupation profile in a specific context and identify with the family the most appropriate goals. Based on the results of this study principles can be given concerning daily activities, adjustments to the environment, adjustments of caregiving approaches and the implementation of activities to be part of a society within the child's motor and visual functional abilities. Due to the occupational field of the researcher, this study focused on functional vision and did not include a full visual assessment using specialised testing material for acuity. Within the field of occupational therapy, this study was just one small step towards better understanding and improving the quality of life for children with CP. The results of the study showed a significant association between eye movements and postural alignment and therefore both the posture and the eye movements are critical to the provision of intervention.

CHAPTER 6

CONCLUSIONS, RECOMMENDATIONS AND LIMITATIONS

6.1 INTRODUCTION

In the previous chapter the results were discussed and interpreted in relation to the research aim and objectives. This final chapter concludes with conclusions and recommendations aimed at further/future intervention studies, after considering the observed limitations and reflection on the study.

The motivation behind this study was based on the need to know whether the motor and eye movements observed in the child with CP will provide insight into how and why these children have difficulties to take part in activities with friends, family and within the greater society. The study was aimed at describing eye movements and postural alignment in sitting as well as determining if an association existed between these two variables.

The researcher has recognised in practice the CP children's needs and motivation to engage in occupational based activities. The researcher had observed *how* the child with CP engaged in the occupations they need, *want* or *have* to do in many aspects of their lives consisting of the many systems that need to be processed simultaneously. This means that many systems can be affected influencing the CP child's success during occupational based activities.

6.2 LIMITATION

At the time the study was executed criterion referenced measures such as the GMFCS, Bimanual Fine Motor Function scale or the Manual Ability Classification to measure functional mobility and activity limitations were not in common use.

At the time of the execution of the study the necessary testing measurement instruments for visual acuity were not available. Therefore the measurement

instrument used in this study for visual acuity was limited in gathering the necessary information needed for better interpretation of the study results.

One of the many challenges the researcher had, was the paucity of validated measures of functional vision and postural alignment that have been shown to be responsive to important change in the functions of occupation-based activities. This study has provided information on what the measuring tools should look like and need to be culture specific and take into account that all tasks have different demands on the posture and the visual system.

Another limitation is that the results are confounded by a relative small population and therefore this study cannot be extrapolated to the general population of children with CP.

6.3 CONCLUSIONS

The most significant, and expected result, is that there is a strong significant association between eye movements and postural alignment. The results showed that children with CP may have deficits in postural alignment that effect eye movements and on the other hand CP children's difficulty moving their eyes efficiently may effect the postural alignment.

The results indicated that children with CP do not have a single cause for their condition but it can be caused by a series of myriad causal pathways that interact in complex ways in a challenging environment. Despite using an assigned CP classification the emphasis should always be on the functional abilities of the child with CP.

More information regarding the CP child's occupational profile, functional level of performances and background information was needed for better clarification of study results. This study has shown that of the issues concerning the functional performances of a child with CP are universal. However, more work is needed to develop the measurement tools which can be used to assess functional vision and postural alignment in cross-culture and in poorly-resource areas in South-Africa.

When working with CP children in any context, it cannot be assumed that the child's functional vision is processed at the same time that other sensory and motor demands are competing for attention. This is particularly true for a sensory complex environment, commonly seen in children with CP. Occupational therapists sometimes overlooked visual impairment because of the neuro-muscular disability. Occupational therapists have to be aware of the association that exists between the control of posture and the visual processing system, when treating children with CP.

The aim for intervention is to establish the CP child's potential for optimal functional vision and to ensure that this is utilised optimally for all areas of development.

It appears that the results in this study, compared favourably with the answers based on the available literature and clinical experience, were adequate to interpret and described the variables under investigation and met the requirements in terms of the data that was obtained.

6.4 RECOMMENDATIONS AND IMPLICATIONS FOR CLINICAL PRACTICE

From the results of this study certain recommendations can be made:

Eye movements should not be disregarded and separated from posture with other functions in the occupational therapy process. The various different functions performed by the brain must be approached holistically and eye movements with the higher functional visual processing difficulties may be a primary postural constraint and may interfere with the occupational therapy process.

Thorough background information could assist the clinical therapist to plan the assessment and intervention.

This was an exploratory and descriptive study which has identified the elements needed for assessing functional vision and postural alignment. The measurement instrument in this study needs to be expanded regarding the following aspect:

- birth history and a day to day activity performance of the child with CP in different contexts. In the absence of the parent the necessary information needs to be gathered beforehand through a questionnaire.
- Structured observation of near and distance vision

Functional measurement instruments may assist undiagnosed visual impairments (due to neuro-muscular disorders that often mask the presence of cerebral visual impairment) commonly seen in CP. It would therefore be useful to have a functional visual assessment that can be used for different settings. A need for OTs to use measurement instruments for functional vision with specific outcomes especially in the field where there is no laboratory based clinics, were established. This could prevent the possible undiagnosed visual impairments due to the neuro-muscular disorders that mask the presence of visual impairment commonly seen in CP.

This study may help to provide direction for future work and studies. It provides the starting point for the validation of measurement tools. Standardised test material could assist an OT to be more specific in planning a holistic intervention of the child with CP for partaking in occupational performances.

Occupational therapists need to have close ties to optometrists and ophthalmologists because of the commonality in treatment and exposure to similar patient population.

Early visual related intervention is of utmost importance in infancy for the maintenance and full development of innate mechanisms that endow the visual system with its highly specific connections.

Not only does the OT need to understand how children with CP perceive people and the environment but also how they use their motor behaviours to respond to the demands of the occupation based activities. Children with central neurological brain damage cover a wide range of clinical presentations and there are no descriptive notes how the child uses his/her eyes functionally in different circumstances and settings. The observations that were used by the researcher for this study may also be improved and used in future studies:

- Focusing on early intervention and/or programs for the maintenance and/or development of visual skills for function.
- Using Criterion referenced measures such as the GMFCS, Bimanual Fine Motor Function scale or the Manual Ability Classification to measure functional mobility and activity limitations.

Repetition of this study should be performed by using standardised measurements.

Therapists need to equip themselves with knowledge and clinical experience by attending post graduate courses and congresses.

This study showed a positive trend in the field of occupational therapy.

6.5 TO CONCLUDE

This was an exploratory study which identified the associations of eye movements and postural alignment in sitting in the frontal plane with children with CP. The research aim was accomplished by describing eye movements and postural alignment. A significant association between eye movements and postural alignment has been established.

“There are no seven wonders of the world in the eyes of a child. There are seven million” – Wait Strightiff

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APPENDICES

APPENDIX A: Information documents and consent documents

APPENDIX B: Instrument measurement: Structured interview, unstructured and structured observation schedules

APPENDIX C: Measuring tool: Structured observation procedures, for eye movements

APPENDIX A

English: **Information letter to parent/guardian:**

Dear Sir/ Madam / Guardian

Thank you for indicating an interest in allowing your child to participate in a research project that will examine your child's eye movements and sitting posture. You are invited to participate and this information leaflet is to help you to decide if you would like to participate. By participation I mean that I am asking you to agree to that your child's eye movements and postural alignment in sitting on a bench without support with feet on floor can be observed.

As an Occupational Therapist I will carry out all research procedures as part of the requirements for completing my Master degree at the University of the Free State. The following outlines the study itself and information about your child's participation.

I am interested in learning more about eye movements and posture alignment in the child of cerebral palsy. I want to know, how the eye movements influence your child's posture or if your child's posture influences your child's eye movements. This information which I learn from this study will be used to improve the therapy that children with cerebral palsy receive.

Participation of your child will consist of your child being observed by myself, for any deviations of posture during sitting at rest on a bench without support and feet on floor. You can sit next to your child on the bench if your child needs support. Hand puppets, a ball and a light will be used to observe your child's eye movements in a stable position that means if necessary your child will be positioned on his back. The observations will take approximately 45 minutes.

I would also like to look in the child's file to confirm diagnoses of cerebral palsy and to confirm any other investigations or interventions.

If after the observations you have questions, it will be answered and discussed immediately

The decision for your child's participation or not is voluntary and will be kept completely confidential. You can stop the procedures of the observations at any time. Taking part in this study will not cost you anything. You will not be paid for participating in this study.

I will not write down your name of your child and all information will be number code to ensure privacy. No information will be released or printed that would disclose any personal identity and all information obtained is strictly confidential.

Thank you.

Contact details of researcher: 018 4686095(W) / 0832931956.

WRITTEN INFORMED CONSENT FORM

I (Parent or Guardian) confirm that I have been satisfactorily informed of the above-described procedure for this study in a language that I understood. I give permission for my child’s participation in this study. I know that Mrs. Scholtz, Occupational Therapists will be available to answer any questions I may have and agree that my child’s file can be check for any information.

I understand that I am free to withdraw and discontinue my child’s participation in this project at any time and by allowing my child to participate, it will not affect my child’s care. I have been offered a copy of this form.

------(Signature of Parent or guardian)

------(Full Name)

I, Christa Scholtz, Occupational Therapist have fully explained to.....

(Parent or guardian), the nature and purpose of the above described procedures.

I have answered and will answer all questions to the best of my ability. I will inform the participant of any changes in the procedures, if any should occur during or after the course of the study.

------(Researcher’s signature)

Mrs.C.E.Scholtz

Occupational Therapist

Tswana:

Batsadi

Ke lebogela go supa kgatlego mo go tseyeng karolo mo porojekeng ya go batlisisa ka ga go tsepamisa seemo mo baneng ba ba sa kgoneng go dirisa matsogo le maoto a bona sentle ka ntlha ya go gobala mo bobokong.

Mme C.Scholtz o tla dira dipatlisiso jaaka karolo ya go peleletsa dithuto tsa gagwe tsa Masters degree kwa Unibesiting ya Foreisetata. Tse di latelang di supa ka ga thuto e, le ka ga kitsiso ya go tsaya karolo ga lona. Fa thuto e, le ka ga kitsiso ya go tsaya karolo ga lona. Fa o tlhoko tshedimosetso kgotsa tlhaloso ka se, o ka o tlhoka tshedimosetso kgotsa tlhaloso ka se, o ka ikgolaganya le nna kwa nomorong e ya mogala (018) 468-6095 / 0832931956.

Maikaelelomogolo a thuta e, ke go tokapatsa kalapo ya seemo mo baneng ba ba sa kgoneng go dirisa matsogo le maoto sentle ka ntlha ya kgobalo ya boboko.

Batsayakarolo ba tle elwa – tlhoko ke ngaka ya marapo go tlhkomela go enyega ga seemo pa fa ngwana a dutse mo setulon se se tlwaelegileng go ikhutsa, le go ela pono ya gagwe tlhoko. Go tla tsaya metsotso e le 45 go dira se. Re tla kopa gape gore ba leke go dira ditiro tse di rileng go bona pa pono ya bona e siame. Go ela –tlhoko go, go tla dirwa ke motlhatlhabi pela le morago ga lenaneo la go tsosa tsa pono, mme e tla tsaya beke di le pedi. Lenaneo la go pa gare le tla dirwa ke mmatlisisi, letsatsi le letsatsi, ka beke tse pedi.

Ga gona kotsi epe e e itsiweng e e golaganngwang le go tsaya karolo. Ka ntlha ya fa se, e sa ntse e le patlisiso fela, melemo ya go tsaya karolo e ka se netepatswe. Ka go tsaya karolo, o tla be o o thusa mo tokafatsong ya kalafo. O tla ithuta go le go ntsi ka methapo ya tsamaiso. Thuto e, e ka nna le melemo e e rileng reposana ka maitemogelo a bona ka lenaneo le mme maitemogelo a bona a diriswa go tliša diphetogo mo lenaneong.

Go tswa mo o wena gore a batla go tsaya karola kgotsa nnya. Batsayakarolo ba ka tloswa mo thutong e, nako nngwe. Dintlha tsotlhe tse di tla bonwang di tla nna sephiri. Mina a batho ga a kitla a dirisiwa. Batsayakarolo ba tla dirisa dinomoro go

tlhkomela gore ba nne mo sephiring. Ga gona dintlha tse di tla kwalwang gope tse di ka supang gore batsayakarolo ke bo mang.

Ke kgotsopaletse kitsiso e pa godimo mme ke thaloganya dikotsi le melemo ya le. Ke neela ngwana wa me tetla go nna motsayakarolo. Ke itse fa Mme Scholtz , le badirimmogo le ene ba tla nna teng go araba dipotso tse ka nnang le tsona.

Ke tthaloganyana gore nka tlogela go tsaya karolo mo porojekeng e, nako nngwe le nngwe. Ke pilwe poromo e, enngwe.

_____ (Tshaeno ya motsayakarolo)

_____ (Tshaeno ya Paki)

_____ (Tshaeno ya motsadi)

-

Ke tthaloseditse _____ (motsadi) ka botlalo dintlha tsotlhe ka lenaneo le. Ke arabile ebile ke tla araba dipotsa tsa gagwe ka moo ke tla kgonang. Ke tla itsese motsaya karolo ka diphetogo tse di nnang teng.

_____ (Tshaeno ya mmatlisisi)

Mrs. C.E. Scholtz

Occupational Therapist

APPENDIX B

APPENDIX B MEASUREMENT INSTRUMENT

STRUCTURED INTERVIEW, UNSTRUCTURED AND
STRUCTURED OBSERVATION SCHEDULES

FOR OFFICE USE

1-3

4-9

10-15

16-17
 18-19

TEST DATE (ddmmyy)

SECTION I

1. DEMOGRAPHIC DATE

1.1. Date of birth (ddmmyy)

1.2. MEDICAL HISTORY

1.2.1 Diagnoses and classification, sub-type CP:

1.2.2 Accompanied impairments:

- 1 Epilepsy
- 2 Hearing impairment
- 3 Other impairments: _____

20
 21
 22

1.2.3 Medication:

- 1 No
- 2 Yes, Specify: _____

23

1.2.4 Previous treatment:

- 1 No
- 2 Yes, Specify: _____

24

1.2.5 Investigations:

- 1 No
- 2 Yes, Specify: _____

25

2. UNSTRUCTURED OBSERVATIONS FOR EYE CONTACT, HEAD CONTROL AND UPPER EXTREMITIES

2.1 EYECONTACT

- 1 Briefly
- 2 Yes
- 3 No

26

2.2 HEAD CONTROL

- 1 Good control in all planes
- 2 Asymmetry to left
- 3 Asymmetry to right
- 4 Need assistance to keep head straight up

27

2.3 UPPER EXTREMITY USE:

- 1 Good grasp with direct reach
- 2 Objects are offered, but does not grasp
- 3 No adequate hand function to grasp

28

3. MILESTONES

Did the child reach the following milestones at the expected age?

MILESTONES	YES (1)	NO (2)	IF YES, WHEN? (MONTHS)
a) EYE-CONTACT			
b) HAND REGARD			
c) HANDS TO MIDLINE			
d) ROLLING			
e) SITTING INDEPENDENTLY			

<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	29-31
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	32-34
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	35-37
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	38-40
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	41-43

SECTION 2

1. STRUCTURED OBSERVATION FOR EYE-MOVEMENT

a) FIXATION	<table border="1"> <tr><td>1</td><td>Good, both eyes are aligned at a distance of 15 cm</td></tr> <tr><td>2</td><td>Loose alignment of one eye at a distance of 15 cm</td></tr> <tr><td>3</td><td>Brief, short</td></tr> <tr><td>4</td><td>Not</td></tr> <tr><td>5</td><td>Different: _____</td></tr> </table>	1	Good, both eyes are aligned at a distance of 15 cm	2	Loose alignment of one eye at a distance of 15 cm	3	Brief, short	4	Not	5	Different: _____	<input type="checkbox"/> 44
1	Good, both eyes are aligned at a distance of 15 cm											
2	Loose alignment of one eye at a distance of 15 cm											
3	Brief, short											
4	Not											
5	Different: _____											
b) FOLLOWING	<table border="1"> <tr><td>1</td><td>Good, follows people, movements, looks at objects</td></tr> <tr><td>2</td><td>Follows only preferential material</td></tr> <tr><td>3</td><td>Follows within his own interesting space</td></tr> <tr><td>4</td><td>Different: _____</td></tr> <tr><td>5</td><td>Does not follow</td></tr> </table>	1	Good, follows people, movements, looks at objects	2	Follows only preferential material	3	Follows within his own interesting space	4	Different: _____	5	Does not follow	<input type="checkbox"/> 45
1	Good, follows people, movements, looks at objects											
2	Follows only preferential material											
3	Follows within his own interesting space											
4	Different: _____											
5	Does not follow											
c) SACCADES	<table border="1"> <tr><td>1</td><td>No over or undershooting is noted</td></tr> <tr><td>2</td><td>Over or undershooting is noted when midline cross</td></tr> <tr><td>3</td><td>Moderate movement of the head or body at any time</td></tr> <tr><td>4</td><td>Large movement of the head or body at any time</td></tr> <tr><td>5</td><td>Large over or undershoot is noted one or more times</td></tr> </table>	1	No over or undershooting is noted	2	Over or undershooting is noted when midline cross	3	Moderate movement of the head or body at any time	4	Large movement of the head or body at any time	5	Large over or undershoot is noted one or more times	<input type="checkbox"/> 46
1	No over or undershooting is noted											
2	Over or undershooting is noted when midline cross											
3	Moderate movement of the head or body at any time											
4	Large movement of the head or body at any time											
5	Large over or undershoot is noted one or more times											
d) VISUAL RESPONSE TO PERIPHERAL Stycarball – 2.5 cm diameter	<table border="1"> <tr><td>1</td><td>Response to peripheral stimulation is appropriate for age</td></tr> <tr><td>2</td><td>The child has a delay turning to look at the ball as it moves into range</td></tr> <tr><td>3</td><td>The child's response is not equal in each eye above, below, right and left of midline</td></tr> <tr><td>4</td><td>Child shown a marked field restriction Specify _____</td></tr> </table>	1	Response to peripheral stimulation is appropriate for age	2	The child has a delay turning to look at the ball as it moves into range	3	The child's response is not equal in each eye above, below, right and left of midline	4	Child shown a marked field restriction Specify _____	<input type="checkbox"/> 47		
1	Response to peripheral stimulation is appropriate for age											
2	The child has a delay turning to look at the ball as it moves into range											
3	The child's response is not equal in each eye above, below, right and left of midline											
4	Child shown a marked field restriction Specify _____											
e) PUPILLARY RESPONSE	<table border="1"> <tr><td>1</td><td>There is a consensual response</td></tr> <tr><td>2</td><td>Each pupils is a different size</td></tr> <tr><td>3</td><td>The pupils do not get smaller</td></tr> </table>	1	There is a consensual response	2	Each pupils is a different size	3	The pupils do not get smaller	<input type="checkbox"/> 48				
1	There is a consensual response											
2	Each pupils is a different size											
3	The pupils do not get smaller											
f) NYSTAGMUS	<table border="1"> <tr><td>1</td><td>No nystagmus</td></tr> <tr><td>2</td><td>Fixation nystagmus</td></tr> <tr><td>3</td><td>Nystagmus present Specify: _____</td></tr> </table>	1	No nystagmus	2	Fixation nystagmus	3	Nystagmus present Specify: _____	<input type="checkbox"/> 49				
1	No nystagmus											
2	Fixation nystagmus											
3	Nystagmus present Specify: _____											

SECTION 3

1. CHARACTERISTICS FOR FUNCTIONAL VISION

PLEASE CHECK ANY AREAS BELOW THAT PERTAIN TO THE CHILD

APPEARANCE

- | | | | |
|--------------------------|-------------------------------------|--------------------------|----|
| <input type="checkbox"/> | Does look blind | <input type="checkbox"/> | 50 |
| <input type="checkbox"/> | Blank facial expressions | <input type="checkbox"/> | 51 |
| <input type="checkbox"/> | Lack of visual communication skills | <input type="checkbox"/> | 52 |
| <input type="checkbox"/> | Eye movements smooth, but aimless | <input type="checkbox"/> | 53 |

VISION FUNCTION

- | | | | |
|--------------------------|-----------------------------------------------------------------|--------------------------|----|
| <input type="checkbox"/> | Visual function varies from day to day or hour to hour | <input type="checkbox"/> | 54 |
| <input type="checkbox"/> | Limited visual attention and lacks visual communication skills | <input type="checkbox"/> | 55 |
| <input type="checkbox"/> | Aware of distant objects, but not able to identify | <input type="checkbox"/> | 56 |
| <input type="checkbox"/> | Spontaneous visual activity has short duration | <input type="checkbox"/> | 57 |
| <input type="checkbox"/> | Visual learning tiring | <input type="checkbox"/> | 58 |
| <input type="checkbox"/> | Closes eyes while listening | <input type="checkbox"/> | 59 |
| <input type="checkbox"/> | Balance improved with eyes closed | <input type="checkbox"/> | 60 |
| <input type="checkbox"/> | Look away from people and objects | <input type="checkbox"/> | 61 |
| <input type="checkbox"/> | Consistently look at either side when visual looking | <input type="checkbox"/> | 62 |
| <input type="checkbox"/> | When visually reaching looks with a slight downward gaze | <input type="checkbox"/> | 63 |
| <input type="checkbox"/> | Turns head to side when reaching, as if using peripheral fields | <input type="checkbox"/> | 64 |
| <input type="checkbox"/> | Uses touch to identify objects | <input type="checkbox"/> | 65 |

MOBILITY SKILLS

- | | | | |
|--------------------------|-----------------------------------------------------------|--------------------------|----|
| <input type="checkbox"/> | Occasionally "sees" better travelling in a car | <input type="checkbox"/> | 66 |
| <input type="checkbox"/> | Difficulties with depth perception, inaccurate reach | <input type="checkbox"/> | 67 |
| <input type="checkbox"/> | Unable to estimate distances | <input type="checkbox"/> | 68 |
| <input type="checkbox"/> | Difficulties with spatial interpretation | <input type="checkbox"/> | 69 |
| <input type="checkbox"/> | Avoids obstacles, but unable to use vision for close work | <input type="checkbox"/> | 70 |
| <input type="checkbox"/> | | <input type="checkbox"/> | 71 |

IMPROVED VISUAL PERFORMANCES

- | | | | |
|--------------------------|--------------------------------------------------------------------------------|--------------------------|----|
| <input type="checkbox"/> | When told "what" to look for and "where" to look | <input type="checkbox"/> | 72 |
| <input type="checkbox"/> | When objects are held close to eyes when viewing | <input type="checkbox"/> | 73 |
| <input type="checkbox"/> | When objects are widely spaced | <input type="checkbox"/> | 74 |
| <input type="checkbox"/> | When looking at one object versus a group of objects | <input type="checkbox"/> | 75 |
| <input type="checkbox"/> | When colour is used to assist in identification of objects or shapes | <input type="checkbox"/> | 76 |
| <input type="checkbox"/> | When objects are against a plain background and paired with movement and sound | <input type="checkbox"/> | 77 |

SECTION 4

1. STRUCTURED OBSERVATIONS FOR POSTURAL ALIGNMENT

1

Sitting position at rest on bench, with feet on floor without back or side support with:

- a) The head aligned with the trunk, in the midline, and level in the horizontal plane (not tilted forward, backward, or sideways);
and
- b) The pelvis in a relatively neutral position (not tilted anteriorly, posteriorly or laterally);
and
- c) The feet placed on the floor in alignment with the knees (not pulled under the bench, or thrust forward, or out to the sides)

78

2

Sitting position; however, **one** of the above criteria (a, b, c) is missing.

Identify the missing criteria or describe the sitting posture

.....
.....

3

Sitting position; however, **two** of the above criteria (a, b, c) is missing.

Identify the missing criteria or describe the sitting posture

.....
.....

4

Sitting position: **all** alignment criteria (a, b, c) is missing.

.....
.....

APPENDIX C

STRUCTURED OBSERVATION PROCEDURES, FOR EYE MOVEMENTS

1.1. Fixation

1.1.1. Material/Equipment:

Penlight (the light source needs to be concentrated and not too strong)

1.1.2. Positioning:

The researcher should ensure that participants with poor head and trunk control have appropriate support by using their adaptive chair and if the participant was not equip with a supportive seat, a supportive position in supine was used. Symmetrical and the most stable starting position of head and body were a requirement.

1.1.3. Procedure:

Hold a penlight between the child's eyes, at eye level, 20-30cm from the nose. Note the penlight's reflections in the pupils. Place your fingers in front of the participant's eye without touching the head, as you cover the the eyes alternately (alternate cover). Cover one eye and quickly uncover it, observe that eye to see its position as it attempts to fixate on the penlight.

1.2. Following/ tracking

1.2.1. Material:

An attractive hand puppet. The size of the puppet needs to be the same as the size of an examiner's hand. A hand puppet made with white material with black paw print is recommended for age 2- 4 years. A hand puppet made with white material with a black smiley face print is recommended for age 4-7 years. A hand puppet made with white material with a black letter or number print is recommended for age 7-10 years. If participant has no interest in the target, use his preferential toy or object.

1.2.2. Positioning:

The researcher should ensure that participants with poor head and trunk control have appropriate support by using their adaptive chair and if the participant was not equip with a supportive seat a supportive position in supine was used. Symmetrical and the most stable starting position of head and body were a requirement.

1.2.3. Procedure

Participants will be observed for the accuracy, ability; head and body movements following a target of four rotations, two rounds clockwise and two rounds anti-clockwise, of 20 cm in diameter, at a distance of 40 cm. Speed of movement: 2 seconds per round.

1.3. Saccades

1.3.1. Material:

Two targets are needed. Use the same targets as described for following. Add the following target and use it for all age groups: Hand size puppet, made with white material with coloured dots randomly spaced, using 4 blue, red, yellow and red dots with each 10mm in diameter. The space between dots, need to be 15 mm apart. If participant has no interest in the targets, use his preferential toys or objects.

1.3.2. Positioning:

The researcher should ensure that participants with poor head and trunk control have appropriate support by using their adaptive chair and if the participant was not equip with a supportive seat a supportive position in supine was used. Symmetrical and the most stable starting position of head and body was a requirement.

1.3.3. Procedures:

Participants will be observed at a distance of 40 cm by using two targets, with each target 10 cm from the participants' midline, the total separation of the targets should be 20cm. Shake one hand slightly to attract the visual attention. Stop with the movement and add a shaking movement to the other puppet to attract visual attention to the second target. Repeat four times (speed between shifts: one second).

1.4. Visual field peripheral response to stycarball

1.4.1. Material:

Stycarball – 2.5 cm in diameter on a rod of 30 cm.

1.4.2. Positioning:

The researcher should ensure that participants with poor head and trunk control have appropriate support by using their adaptive chair and if the participant was not equip with a supportive seat, the parent or guardian can place the child on their lap in the best position for comfort, motor stability and head control.

1.4.3. Procedures:

Have a helper stand behind the child. The tester, in front of the child, tries to get the child to fixate on his/ her face or by using one of the previous hand puppets. Once the child fixated directly ahead the helper is given a signal to move the ball forward from behind the child about 40 cm from child's head towards the central visual field in an arch. Repeat by presenting the target several times coming from the left, right, above and below midline. Note at which point in the field of vision the child notices the object. Take care that the participant does not see the target by maintaining his or her interest in the central visual field.

1.5. Pupillary response

1.5.1. Material:

Penlight (the light source needs to be concentrated).

1.5.2. Positioning:

The researcher should ensure that participants with poor head and trunk control have appropriate support by using their adaptive chair and if the participant was not equip with a supportive seat a supportive position in supine was used. Symmetrical and the most stable starting position of body and head were a requirement.

1.5.3. Procedure:

Hold the edge or your hand on the child's nose, to block the light of the penlight from one eye, and then briefly shine the penlight in the eye that is not blocked. Both pupils should constrict.

1.6. Considerations:

The following considerations were taken into account during the structured observation schedules:

- A well illuminated room was allocated for the researcher at each research site.
- The observational area was quiet, free from external distractions and had the necessary space and equipment.
- The researcher should ensure that children with poor head and trunk control have appropriate support by using their adaptive chair and if the child was not equip with a supportive seat a supportive position in supine was used.
- Symmetrical and the most stable starting position was a requirement.

1.7. Posture alignment

1.7.1. Material

Adjustable bench with no side- and back-rest

1.7.2. Positioning

The child was placed with the head in the midline and the trunk as straight as possible on a bench next to the parent or guardian. The child was sitting on a bench without arm and back supports with feet touching the floor. The bench was adjustable to accommodate the height. The 90.90.90 (cf. 2.6.1) sitting principle was used, ninety degrees at the hips, ninety degrees at the knees and ninety degrees at the ankle.

1.7.3. Procedures

For purposes of this study, a plumb line was used in the anterior view to serve as a point of reference coinciding with the midline of the trunk and head (Edwards 1996:24; Kendall & McCreary 1983:19). The child was placed by the parent or guardian in sitting on the bench as described and asked to look at the researcher who was standing two meters from the child. The support was only withdrawn by the parent or guardian when the child felt comfortable without crying. The moment deviations were detected the observations were terminated immediately (cf. 3.4.2.7).