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Electronic Device Use and Fine Motor Dexterity & Handwriting in Grade 2 Elementary School children

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Electronic Device Use and Fine Motor Dexterity & Handwriting in Grade Elementary School children

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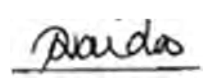
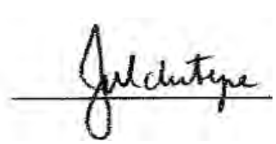
Pragashnie Govender 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ABSTRACT

Aim*: The study aimed to investigate whether a correlation exists in the electronic device usage and fine motor dexterity and handwriting in Grade 2 elementary male and female children.*

Methodology: *A quantitative, correlation study design was utilized. Stratified sampling was employed to select n=34, grade 2 children together with their parents/primary caregivers. A parental self-administered questionnaire measured the electronic device type and frequency of use by the children. The children's fine motor dexterity was measured with the Nine-Hole-Peg-Test and handwriting was measured with the Minnesota Handwriting Assessment. Data was analysed using SPSS version 22.*

Results and Discussion*: Touch screen cellular phones and standard size tablet computers were most frequently used. The mean total time per week spent on electronic devices amounted to 9.3 hours and 5.5 hours per week across all mobile devices. Statistical significant correlations were measured for; total device use and total handwriting score (rho=0.110), total device use and non-dominant hand's dexterity (rho=0.137), weak trunk stability and handwriting speed (p=0.007), male children's handwriting speed was superior (p=0.015) and female children's form of handwriting was superior (p=0.005), male children used handheld videogames more than female children (p=0.001).*

Conclusions*: A weak positive correlation exists between the total time spent on electronic device usage in a week and non-dominant dexterity and handwriting. This implies that more frequent total electronic device usage per week has a higher handwriting total score but weaker non-dominant hand dexterity as a result. No correlation existed between total usage and dominant dexterity. Gender differentials revealed that males displayed faster and superior total scores in handwriting, females displayed superior scores for form, alignment and spacing and dominant/non-dominant hands' dexterity.*

Keywords: *Fine motor dexterity, handwriting, Grade 2, electronic devices*

TABLE OF CONTENTS

CHAPTER 2: LITERATURE REVIEW

CHAPTER 3: RESEARCH METHODOLOGY

CHAPTER 4: RESULTS

CHAPTER 5: DISCUSSION

CHAPTER 6: CONCLUSIONS

LIST OF TABLES

PAGE

LIST OF FIGURES

PAGE

LIST OF APPENDICES

PAGE

OPERATIONAL DEFINITIONS

Affector

The hand acts as a sensory information gathering tool that relays valuable information regarding the environment to the brain for interpretation (Mennen & van Velze, 2008).

Attention Deficit Hyperactivity Disorder

"Poor or short attention span and impulsiveness inappropriate for the child's age; some children also manifest hyperactivity." (Merck, 2003)

Congenital Condition

A disease or illness that is genetically inherited (Merck, 2003).

Developmental Milestones

The set of skills and abilities that are demonstrated by specified ages during early childhood with regards to hand fine motor dexterity and handwriting skills (Merck, 2003).

Down Syndrome

"A chromosomal disorder resulting in mental retardation and physical abnormalities." (Merck, 2003)

Effector

In this capacity the hand is operating as a functional tool that works and performs tasks (Mennen & van Velze, 2008).

Fine Motor Dexterity

"The ability to make rapid, skillful, and controlled manipulative movements of small objects, using primarily the fingers". And "the fine, voluntary movements used to manipulate small objects during a specific task as measured by time required to complete the task." (Fleishman & Ellison, 1962)

Fragile X

A syndrome with genetic abnormalities in the X chromosome that leads to developmental delay and other symptoms (Merck, 2003).

Frequency of Electronic Device Usage

Time spent on electronic device use, divided into use during each day of the week.

Handwriting Legibility

The qualitative aspect of the written work and includes components of letter formation, letter size, letter or word spacing, letter alignment and letter slant (Amundson, 2005).

Handwriting Speed/Rate

Writing done with a pencil as fast as possible while the writing is still legible. Handwriting speed also refers to the quantitative aspect of the written work and is the measurement of the letters written within a specific time period (2.5 minutes) (Van der Merwe, Smit & Vlok, 2011).

Letter Alignment: The placement of the letters within and on the lines of the page (Amundson, 2005).

Letter Formation

It incorporates aspects such as how letters are formed, letter rounding, additional strokes, letter reversals, missing strokes, letter closure, letter ascenders/descenders and leading in and out of letters. Superior legibility can be assumed when the above components are accurate (Amundson, 2005).

Letter Size: Relates to the size of the letters in relation to the other written letters and to the lines on the page. Letter and word spacing can be defined as the open spaces between letters in a word and words in a sentence (Amundson, 2005).

Mobile Devices

Mobile devices in this context can be defined as any hand-held, small in size, device with a touch display screen or a miniature keyboard. These mobile devices more often than not, allow connections to the Internet.

Slant of the Letter: Refers to the angle at which the letter is written. There are variations that can be expected in this regard, vertical aligned, sloped to the left or sloped to the right letters (Amundson, 2005)

Type of Electronic Device

Refers to what specific devices were being used by the Grade 2 male and female elementary school children at that specific time period. The options in the questionnaire were tablet (standard size), tablet (mini size), desktop computer, laptop computer, video games (console), video games (handheld), cellular phone (touch screen/smartphone), cellular phone (manual) and an option of other.

LIST OF ABBREVIATIONS

SA	South Africa/African
USA	United States of America
MHA	Minnesota Handwriting Assessment
NHPT	Nine-Hole-Peg-Test
ETCH	Evaluation Tool of Children’s Handwriting
THS	Test of Handwriting Skills
CHES	Children’s Handwriting Evaluation Scale
WRIT	Writing Rate Information Test
GDE	Gauteng Department of Education
ISASA	Independent Schools Association of South Africa
ADHD	Attention Deficit Hyperactivity Disorder
ADD	Attention Deficit Disorder
SPSS-22	Statistical Package for Social Sciences version 22
BREC	Biomedical Research Ethics Committee

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

Fine motor dexterity relates to the in-hand manipulation of objects, especially in the use of writing utensils which makes the human hand the most developed organ for prehensile use among all living creatures and it distinguishes humans from any other species (Mennen & van Velze, 2008). To emphasise the highly specialised capacity of the hand, it not only serves as an advanced "effector" with its 38 muscles in the hand to perform tasks, but it also acts as an "affector" through touch (Mennen & Van Velze, 2008). The hand can sense touch, pain and temperature like no other part of the body with its highly specialised and larger motor/sensory cortex representation in the brain. To this end, the hand has enormous capacity and from a young age acts as the tool to explore the environment that surrounds us.

This research study, in partial fulfilment of a Masters in Hand Rehabilitation degree, is undertaken to get insight into the "hands" of 7 to 8 year olds, with respect to the fine motor dexterity and handwriting. Henderson & Pehoski (2006) states that adequate fine motor dexterity is a crucial prerequisite to fluent and age appropriate handwriting development. This becomes even more crucial in the foundation schooling phase where the academic curriculum places emphasis on writing readiness from as young as 5 to 6 year old children (Van der Merwe, 2011). To this end the study endeavours to measure both the fine motor dexterity and handwriting ability of children compared to their electronic device usage.

Feder & Majnemer (2007) emphasised this relationship between fine motor dexterity and handwriting further by stating a correlation exists between the two variables and visual motor integration.

As far as the researcher is aware, market research reports on electronic device usage in children between the ages of 7 to 8 years old, are lacking in the South African (SA) context and for this reason, market research conducted in the United States of America (USA) will be utilised to give valuable insight into type and frequency of electronic device use. Modern electronic devices that surround Grade 2 children are increasingly used by younger age groups. Children, as young as 2 years old use electronic devices, where a number of years ago the stimuli that young children used to explore the environment were very different, than cellular phones and tablet computers. The researcher is of opinion that the increase in electronic media devices can also alter children’s play activities, time management, learning aids and as will be investigated in this research, potentially their fine motor dexterity and handwriting abilities.

This research study was an attempt to answer the formal plea by researchers (Wartella & Vanderwater et al, 2005) and the informal plea of parents and teachers, on the topic of how electronic media impacts and are being used by the SA child with respect to handwriting and fine motor dexterity.

In this chapter the background to the research question will be posed, with the problem statement and research hypotheses. The study aim and objectives that will guide the research process will follow with an outline of the study concluding the chapter.

1.2 BACKGROUND TO THE STUDY

Tofler (1980) describes three waves of human societal evolution, the first wave being from hunter-gatherer to agricultural society, the second from agricultural to industrial based society, and the third wave from industrial to information based society. Personal computers have become a primary tool in the development of this information based society, contributing towards a sedentary and arguably less active and healthy lifestyle.

Taking into account the rise in electronic devices, the variety in choice for the young consumer and the increase in the frequency of use measured in the USA, will be unpacked in the literature review. The question, of what the possible effect of these electronic devices could have on the fine motor dexterity and handwriting in school children is thus posed. The unique needs of the pre-school population with regards to developing age appropriate video games are an evolving topic of research (Bryant, Akerman & Drell, 2010). Designing video games for the young consumer needs to take in consideration their motor skills, cognitive abilities and certain design preferences (Bryant et al, 2010). The reality is that young children still play video games at home with controllers that are oversized for the smaller hand.

In these children, from Grade 0 to Grade 3 (children turning 5 years of age in Grade 0 up to children turning 9 years of age in Grade 3), instruction in a school day still focusses predominantly on fine motor dexterity and handwriting development. The time spent on fine motor dexterity and handwriting instruction can amount to more than 50% of a school day (Van Hartingsveldt, 2011; Tseng & Chow, 2000), where 85% is spent on handwriting instruction. The electronic device use during the school day is still limited due to a structured program in Grade 0 to Grade 3, whereas the electronic device usage is assumed to take place during the recreation time, after the formal school day and over weekends. An influx of tablet computers and desktop computers in schools is observed from Grade 4 onwards and it is of concern that a declining emphasis could possibly be placed on handwriting in the elementary school curriculum. To further emphasize this point, increased use of tablet computers can possibly decrease the use of pen and paper in the classrooms (Straker, Coleman & Skoss, 2008). Due to this, children could be encouraged to develop typing/keyboarding skills. Further, handwriting instruction is under scrutiny in the educational circles and great controversy exists in key areas in handwriting *inter alia*, the teaching of manuscript and cursive, when typing on computers are used more frequently in modern society, some critics argue that instruction in cursive handwriting is not applicable to the modern society. According to the Hanover Research (2012) all but five USA states adopted the Common Core Standards in their elementary schools, thus highlighting that cursive handwriting is substituted by keyboarding and more advanced technological-based learning with regards to literacy development, if the schools deem it fit.

It is not only the time management of children that are being altered by electronic devices, but more importantly is the concern about correct cognitive development of the child that accompanies the correct handwriting development (Henderson & Pehoski, 2006). The hand has a large motor cortex representation and thus involves higher order cortical processes that are at work when the small hand muscles are busy with fine motor dexterity and handwriting tasks. It is imperative to encourage future research in the area in order to have an improved understanding of what the possible effects of an increased electronic device usage could be, may it be positive, negative or no effect at all.

An understanding of the interplay between types of electronic devices being used, the frequency of use and handwriting and fine motor dexterity scores can help teachers, occupational therapists and hand therapists, to channel their intervention, teaching and therapies.

1.3 PROBLEM STATEMENT

The modern era is characterised by an increase in electronic devices, with electronic media being at an all-time high in contemporary society (Common sense media, 2013). The developmental impact of these devices on children is mostly unknown. In particular, limited empirical literature exists on the interaction effects between the latest electronic devices and children's handwriting at the foundation phase level of schooling.

To the researcher's knowledge and based on a perusal of the available literature, it appears that no comparative studies have been undertaken to compare electronic device use, fine motor dexterity and handwriting in the SA context.

1.4 STUDY AIM AND OBJECTIVES

The aim of the study is to determine whether electronic device usage has an effect on the fine motor dexterity and handwriting amongst Grade 2 elementary school children.

Specific objectives include the following:

- To describe the frequency and type of devices used by Grade 2 male and female children.
- To measure the fine motor dexterity of the Grade 2 male and female children using the NHPT.
- To measure the handwriting of the Grade 2 male and female children using the MHA.
- To determine any gender differences in electronic device frequency/ type of use, fine motor dexterity and handwriting.
- To compare frequency of use and, type of electronic device with fine motor dexterity and handwriting.

1.5 NULL HYPOTHESES

- H_0 There will be no significant difference in the frequency of electronic device use and handwriting ability
- H_0 There will be no significant difference in the frequency of electronic device use and fine motor dexterity
- H_0 There will be no significant difference in gender and type of electronic device use
- H_0 There will be no significant difference in gender and total electronic device use
- H_0 There will be no significant difference in gender and fine motor dexterity of the dominant and non-dominant hands
- H_0 There will be no significant difference in gender and total handwriting score

- H_0 There will be no significant difference in gender, handwriting sub-categories and fine motor dexterity
- H_0 There will be no significant difference in total device use and fine motor dexterity
- H_0 There will be no significant difference in total device use and handwriting
- H_0 There will be no significant difference in total device use and handwriting subcategories
- H_0 There will be no significant difference in gender and type of electronic device use
- H_0 There will be no significant difference in gender and total electronic device use
- H_0 There will be no significant difference in gender and fine motor dexterity of the dominant and non-dominant hands
- H_0 There will be no significant difference in gender and total handwriting score
- H_0 There will be no significant difference in handwriting scores and faulty observations
- H_0 There will be no significant difference in handwriting subcategory scores and faulty observations

1.6 TYPE OF STUDY AND METHODS

A quantitative correlational study design was used in order to ascertain the correlation between electronic device use, fine motor dexterity and handwriting, as well as to describe features of the population, such as handwriting, fine motor dexterity, type of electronic device use, frequency of electronic device usage and gender differentials.

1.7 OUTLINE OF STUDY

Chapter 2 (Literature Review) will highlight handwriting, fine motor dexterity and electronic device usage in children. A physiological section will be included to emphasise the importance of optimal fine motor dexterity, hand and handwriting development in the early childhood phases. A section that mentions market research, on electronic device types, frequency and age of use, was included to give valuable information that contextualised the increase in usage among children.

Chapter 3 (Methodology) will cover the methods used in; sampling the population, inclusion criteria, exclusion criteria, data collection instrument and procedures, data management, statistical analysis, ethical principles guiding the study, reliability and validity of the included tests.

In Chapter 4 (Results) an overview of the results will be given in an attempt to answer the aim and objectives of the study, as well as to accept or reject the null hypotheses.

Chapter 5 (Discussion) will include a discussion of the results mentioned in Chapter 4 and relating it to relevant literature, in order to unpack and contextualise the results.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

There is little doubt that electronic devices makes one's life easier and that there is an increased reliance on computers and cellular phones in this era. It alters the lives of people particularly that of children, and therefore an improved knowledge regarding the interaction between children and their most frequently used electronic devices appear to be of paramount importance. This literature review will offer an overview of handwriting importance, the interaction between fine motor dexterity and handwriting, prevalence of handwriting problems, handwriting development and the cognitive importance of developing fluent handwriting. Thereafter, an overview of electronic devices, including difficulties that certain devices pose for young users' hand function, age of use, type of devices and statistics of use is presented.

The discussion of the review of the literature that follows covers the following important areas; fine motor dexterity, handwriting importance and development, review of tests during the selection process and electronic device types and use.

2.2 FINE MOTOR DEXTERITY DEVELOPMENT AND ITS INVOLVEMENT IN HANDWRITING

Fine motor development refers to the fine motor actions of the small hand muscle and this skill is used in tasks such as cutting, grasping of objects and writing. Adequate fine motor development is crucial in producing good handwriting tasks with legible letters produced at the correct speed (Henderson & Pehoski, 2006). Tseng & Murray (1994) postulated that children with good handwriting scored higher on fine motor tests than children with illegible handwriting. Fine motor dexterity also plays an important role in the use of electronic devices, especially in the use of handheld video games, cellular phone and tablet computers. The aim of this study is thus to determine whether a possible connection exists between fine motor dexterity and handwriting in the presence of electronic device use.

2.3 HANDWRITING IMPORTANCE AND DEVELOPMENT

Handwriting has been posited as the most important skill children learn in their first school years with a school day consisting of thirty to sixty percent of time devoted to fine motor development, with the predominant task being handwriting (Van Hartingsveldt, 2011; Tseng & Chow, 2000).

Handwriting determines the success, self-esteem and communication of children in their school career and according to the Kwa-Zulu Natal Department of Education (2006) adequate writing skills are imperative for children to be able to "express their thoughts, feelings and ideas for both themselves and the intended audience". The importance of handwriting can also be seen in how elementary school children's handwriting was viewed by their teachers and peers as a reflection of their capabilities and intelligence. According to McHale & Cermak (1992), a study that was conducted more than twenty years ago, already then peer judgements were made between children based on the neatness of their handwriting. There is support in recent literature where lower marks have consistently been assigned to poor handwriting and higher marks allocated to students with legible handwriting, even when the content of their work is similar (Conelly, Gee & Walsh, 2007). Early success in handwriting is thus imperative for children's future academic success and experience, because difficulties often persist well into their formal education (Naidoo, Engelbrecht, Lewis & Kekana, 2009).

Prevalence of handwriting problems' has been documented as being between 5% to 27% of the population, with these figures being dependent on the selection criteria, assessment instruments used and grade level in the studies (Volman, van Schendal & Jongmans, 2006). Handwriting difficulties have been reviewed extensively in the literature and can be categorised as having either intrinsic and/or extrinsic underlying aetiological factors (Feder & Majnemer, 2007). These variables will be named to highlight the complexity of handwriting. Extrinsic variables were reported to include insufficient time dedicated to formal handwriting instruction, inefficient teaching methods, ergonomics or environmental factors (Christensen, 2005). Intrinsic variables included difficulties with visual motor integration, motor learning, motor planning, postural control, sensory integration, visual perceptual skills, orthographic-motor integration and orthographic coding, kinaestheia, eye-hand coordination, fine motor skills, memory, expressive language, motivation and phonological awareness (Feder & Majnemer, 2007; Zwicker, 2005).

Graham, Berninger, Weintraub & Schafer (1998) found that handwriting competence is usually described in terms of legibility, with features of poor handwriting legibility including; producing smaller letters, added strokes, and exhibiting more variability in spacing and alignment. Handwriting skill is not an automatic process, but rather requires intentional sufficient practice after formal instruction. Zwicker, (2005) reported that “motor skills are resistant to change and the need for them to be developed accurately in the early stages of development is very important for handwriting.” Further emphasising this point, certain handwriting problems have its origin in the early foundation years of childhood development and can be due to intrinsic challenges. Therefore it is crucial to understand the various stages of handwriting development which will now be further expanded on.

Feder & Majnemer (2007) and Henderson & Pehoski (2006) described handwriting development that begins with early scribbling, becoming more intentional over time. These early scribbling patterns evolve into more precise shapes, progressing to letters, with these letter shapes being seen in some children’s drawings. This can be viewed as a precursor for handwriting. Printing letters are learned by first imitating geometric shapes beginning with vertical strokes at 2 years of age, followed by horizontal shapes at 2.6 years of age and circles at age 3 years. Imitation and then copying a cross occurs at 4 years of age, copying a square at 5 years of age and a triangle at age 5.6 years. Copying geometrics forms, particularly the oblique cross, is seen as an indication of writing readiness in young children, because it requires crossing the body midline and is implicated as the root of many problems with letter reversal.

Handwriting development in childhood starts by first grasping the writing instrument with a palmar- or power grasp, involving using the fingers and palm to grip the writing instrument. The progression is to a tripod grasp, where the writing instrument is held more firmly between the thumb and first two fingers. A dynamic tripod grasp, which is considered as a crucial developmental milestone, is learned at ages 4 to 6 years and is required for drawing finer details. This crucial developmental milestone depends on the effective use of very small hand muscles that produces movements of the fingers and thumb to achieve the dynamic tripod grasp (Braswell, Rosengren & Peirroutsakos, 2007). Children who did not master this stage of handwriting development and who are using electronic devices more frequently are of great concern, because of the unknown effects of oversized video game controllers on intrinsic hand muscles strength. Handwriting studies of typically developing children aged 6 to 11 years have been undertaken and shows that the quality of handwriting develops quickly during grade 1 (ages 6-7 years) and plateaus by grade 2 (ages 7-8 years). In grade 3 (ages 8-9 years) handwriting becomes automatic and organised and is used as an idea development tool (Feder & Majnemer, 2007).

Within the above context, this study thus aims to examine handwriting skills of elementary school children in grade 2, as literature suggests that handwriting skill should be well-developed at this stage and, hence, testing thereof more reliable (Feder & Majnemer, 2007; Karlsdottir & Steffansson, 2002). Further, research into handwriting development suggests that, from age 7 years, significantly lower handwriting quality and speed is demonstrated by boys compared to girls (Ziviani & Watson-Will, 1998). This study endeavours to examine any gender differentials between the selected grade 2 children on the East Rand of Gauteng

It can be postulated that a poor and illegible handwriting has an impact on the higher-order cognitive processes, and this section will illustrate this, relating to neurophysiological literature. Henderson & Pehoski (2006) made mention of the existence of direct corticospinal connections when the fingers are moved independently. The connections extend to the alpha motor neurons of the hand and the primary motor cortex of the brain. An important exception was discovered regarding the termination of the corticospinal tract in the spinal cord to the distal extremity. Normally most descending motor fibres first terminate in the interneuronal zone but the distal extremity is different in this regard, where direct corticospinal fibres to the alpha motor neurons of the distal extremity were found. The direct path facilitates speed and skill in the hand. Maier, Armand & Kirkwood (2002) mentioned that these special connections are thought to be preferentially related to intrinsic hand muscles. In handwriting with the preferred dynamic tripod grip, these intrinsic muscles are predominantly used and thus the cognitive connection can be observed. The cognitive importance of hand function can further be seen where the primary motor cortex is of paramount importance in independent finger movements. The neurons that are the source of direct corticospinal connections are more numerous in the hand area of the primary motor cortex than connections from other cortical areas. Damage to the primary motor cortex or corticospinal tracts were investigated and found to result in a decreased precision grip, decreased independent finger movements and a deficit in fine manual coordination (Fogassi L, Gallese V, Buccino G et al, 2001). In the last few years a significant research finding was made with regards to the functional organisation of the primary motor cortex (Classen J, Liepert J, Wise SP et al, 1998). The functional organisation is dynamic and changes to use, where use-dependent changes have been seen in the motor cortex of humans. According to Butefisch (2004) there are numerous representations of the hand in the motor cortex and they represent overlapping representations, functionally connected through a horizontal network between neurons. Dynamically changing patterns can be achieved by changing the strength of the horizontal networks through repetitive practice or use. In the above context, the frequent use of electronic devices by young children and its unknown effect on the strength of these horizontal networks, related to handwriting has prompted this study.

2.4 REVIEW OF TESTING METHODS

Standardised tests were considered for the testing of the Grade 2 research participant's fine motor dexterity and handwriting in this study. The following two headings will guide the review process: Fine motor dexterity tests and Handwriting Assessments.

2.4.1 Fine motor dexterity tests

Three standardised tests were considered prior to the testing of fine motor dexterity. The Purdue Pegboard Test is a test equipped with washers, collars and pins located cups at the top of the board. This test was omitted due to the validation study that was performed on an adult population (Smith & Hong, 2000).

The Grooved Pegboard consists of 25 metal pegs with a pegboard that has 25 grooved holes arranged in rows of five. The shape of each hole is identical, but the variation lies in the orientation of the holes. Children that participate in this assessment are instructed to only complete two rows of the pegboard. This test was omitted, because of the longer administration time required to complete and it poses a greater challenge to children (Wang, Magasi, Bohannon et al, 2011).

The Smith and Nephew Rolyan NHPT consist of nine plastic pegs (0.6 cm in diameter) with a moulded dish next to the pegboard (31 x 26 x 4 cm) with holes where the pegs must be inserted. The children tested with this test are instructed to put the nine pegs in the pegboard holes, take them out and place them back in the moulded container as fast as possible. The time in seconds are measured by a stopwatch that comes standard with the test. The stopwatch can measure time to the closest millisecond. The NHPT was selected for this research study, because of the simple, efficient, short administration time (3 minutes) and it's a low cost measure of assessing fine motor dexterity. The test-retest reliability coefficients for right and left hands were measured at 0.95 and 0.92, respectively. The NHPT also correlates with the Purdue Pegboard at -0.74 to -0.75 (Wang et al, 2011).

2.4.2 Handwriting Assessments

The assessment of handwriting can either be conducted formally and/or informally and there are various standardised tests available to improve the objective measures, help monitor the child's progress and aid professional communication. Most standardised tests measure the legibility of the written work and then different legibility components, such as speed (Van der Merwe et al, 2011).

Five standardised handwriting assessment tests were considered for this research study. The parameters included Grade 2 subjects, manuscript handwriting, short duration and a comprehensive measurement of handwriting. The tests reviewed and their developers were as follows, Evaluation Tool of Children's Handwriting (ETCH) (Amundson, 1995), the Test of Handwriting Skills (THS) (Gardner, 1998), the Children's Handwriting Evaluation Scale (CHES) (Phelps & Stempel, 1984), the Writing Rate Information Test (WRIT) (Steinhardt, Richmond & Smith, 2005) and the MHA (Reisman, 1999).

A short overview of the strengths and weaknesses of the above mentioned tests will be discussed. The ETCH has a 3 Level of Evidence and a good content and face validity. The ETCH evaluates manuscript as well as cursive font types, but due to the testing period being in the beginning of the year the school curriculum only requires manuscript proficiency. It considers a wide range of tasks and testing domains (Collins, Candler & Sanders, 2008). The weakness of the ETCH lies in its low and varied interater, intrarater and test-retest reliability scores (Henderson & Perhoski, 2006). Also the time for the administering (15-30minutes) and scoring (10-20 minutes) of the test made it impractical for this study, due to time restraints.

The THS was excluded due to the lack of legibility scoring, uncertainty about level of evidence and reliability and lastly because of the time it takes to administer (15-20 minutes) and scoring (15-20 minutes).

The CHES has a 3 Level of Evidence and a short administering (2 minutes) and scoring (3-7 minutes) time (Collins et al, 2008). The interrater reliability ranges from 0.88 to 0.95. It was omitted due to the lack of evidence whether it can discriminate between poor and good writers and not only the extremes (Henderon & Pehoski, 2006).

The WRIT is developed for the SA context, it is a non-standardised test that provides norms for a SA population and it measures writing speed. It was omitted because no reference could be found on its reliability and validity (Steinhardt et al, 2005).

The MHA has a 3 Level of Evidence and short administering (2.5minutes) and scoring (3.7minutes) time (Collins et al, 2008). It has been shown to have good inter and intrarater reliability and the assessment score sheet covers handwriting form, spacing, size, alignment, legibility and speed in very district sections (Henderson & Pehoski, 2006). Due to the its reliability and validity in the measurement of handwriting, extra handwriting observational assessments, as well short administering and scoring times, the MHA was selected as the evaluation test for this research study.

2.5 ELECTRONIC DEVICES: TYPES AND USAGE

Revelle & Medoff (2002) investigated electronic device use by children and indicated reasons as to why home entertainment systems, computers and other electronic gaming devices are often difficult for preschool children to use. Electronic devices that are frequently found in households are being used by young children, but are designed for the adult target population. These children find it difficult to manipulate the controller with its small buttons. Difficulties are also experienced as preschool children lack the required fine motor control, cognitive understanding of the mapping between controller use and the on screen activity. Further the abstract thinking skills to be able to understand the representational nature of the concepts on the video games are lacking. To this end, specifically designed video games for preschool children are increasing, but still limited.

Bryant, Akerman & Drell (2010) considered the relationship between common household media devices and the required fine motor skills necessary for their use. This literature was reviewed because of the importance of fine motor skills in good handwriting and the lack of it is often implicated in common handwriting errors. By way of example, the Nintendo DS and other handheld devices require recruitment of fine motor skills for its manipulation and use. In contrast the Nintendo Wii requires broader movements involving primary gross motor skills (Bryant, Akerman & Drell, 2010). Electronic media devices are being used by young children and half of all young children use computers or smartphones before the age of 2 (Common sense media, 2013). Literature further illustrated children's electronic device usage, by way of example, children as young as 5 years of age use cellular phones and tablet computers, with schools utilising tablet computers as learning aids for children (Straker, Coleman & Skoss, 2008). In 2011, 10% of children under the age of two had used a mobile device and that has increased to 38% (Common sense media, 2013).

Market research and empirical literature offers various statistics and trends related to the use of media devices by children. By way of example, computer and consoles are reported to comprise 27% of children's daily media consumption (USA Market Research Report, 2013), with 50% of American pre-school children having console video game players at home and 28% having hand-held video games (Rideout & Hamel, 2006). Of these children, 29% who played console video games and 18% who played hand-held games were below the age of 6 years (Rideout & Hamel, 2006). These findings are of concern, given that the majority of gaming equipment is designed for an older audience and not intended for use by children, but on entering a family home, are frequently used by children of that household, many between the ages of 2 to 6 years (Bryant et al, 2010). Another popular media device being frequently used by preschool children is the iPhone or iPod Touch, with 20% of parents thinking that it is an appropriate play activity (Nickelodeon, 2009).

Further market research and statistical trends will now be mentioned to contextualise the increase in electronic devices use and the different types of devices frequently used by children aged 0 to 8 years old. Children are entertained by multiple devices and television is still the main device of use and its importance growing. Tablet computer rates of use are up and are 8% of the daily media usage. There is an increase in computer and smartphone usage, but gaming is still the number one activity across devices. For gaming purposes, computers are being used by 96% of children, 88% use tablet computers and 86% of children use smartphones. The age analysis from zero to eight year old children with regards to media usage during 2013 will be mentioned. The number of children who have used mobile devices has almost doubled since 2011 from 38% to 72%. The average daily use of mobile devices has tripled from 5 minutes to 15 minutes. Among children up to the age of eight, an average of 17 minutes a day is spend on using a computer, 14 minutes a day using a console or handheld videogame player, 5 minutes using a cellular phone, video iPod, iPad and 1 hour and 40 minutes watching television (Common Sense Media, 2013).

2.6 SUMMARY

There is little doubt that a decrease in handwriting skill will adversely impact children in our society. Handwriting development is not only crucial in the success of the child’s school career, but aids in developing crucial cognitive abilities that impacts normal development on all levels.

It could be presumed from the above literature review and discussion that should a correlation be found between the electronic device usage and handwriting, preventative measures should be introduced. An awareness regarding proper recreational time management, age appropriate electronic devices and video games, as well as developmental play activities can greatly benefit SA children with regards to normal childhood development.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

In this chapter, the study area, study population/sample and selection procedures of the schools and participating children will be explained. Following that, a detailed explanation of the inclusion/exclusion procedures, data collection instruments and procedures will follow. The methods that were used to achieve the objectives will also be unpacked.

3.2 OVERVIEW OF METHODS AND OBJECTIVES OF THE STUDY

The study followed a quantitative, correlational design which involved the testing of a representative subset of the population of Grade 2 school male and female children and their parents/primary caregivers. A systematic sampling method guided the sampling procedures. A researcher administered test, the MHA, measured overall handwriting and the NHPT measured the fine motor dexterity of the Grade 2 children. Self-administered questionnaires for their parents or primary caregivers investigated the electronic type and frequency of use of the research participants.

3.2.1 Advantages and Disadvantages of Correlational Research

The advantages of choosing a correlational design for this study is seen where the result can be applied to the “everyday life” of a school child in Grade 2 because data was collected in the school setup and not in a laboratory. For a first time study, investigating the variables under question, a correlational study succeeds in determining the direction and strengths of the relationship of these variables and in so doing stimulate further experimental studies to determine causation (Filipowich).

Disadvantages of a correlational design includes aspects such as; it assists to determine a relationship between variables but no conclusive causation can be drawn from the results whether on variable influences the other (Filipowich).

3.3 STUDY AREA

Purposive sampling was used in the selection of English-medium Private schools in the East Rand (Kempton Park, Boksburg, Germiston and Benoni) of Gauteng Province, SA. The multiple contacts required with the schools and the different phases of data gathering, made the accessibility of the participants to the researcher and the fieldworker imperative. Thus, schools were selected in the East Rand, Gauteng which was accessible to the fieldworkers. Private school children in Grade 2, were selected from a list of Independent Schools obtained from the Gauteng Department of Education (GDE). The rationale for the inclusion of private schools were to find an English speaking sample population that potentially use more electronic devices, because of the socio-economic status of the households (Zarghom, Fonzo & Coutts, 2013).

3.4 STUDY POPULATION

The study population comprised all Grade 2 male and female elementary school children, in private schools and predominantly co-educational educational programmes, on the East Rand of Gauteng Province in SA; in the following suburbs; Kempton Park, Boksburg, Germiston and Benoni. Table 1 (N=1392). A telephonic survey was conducted prior to the commencement of sampling, amongst the private schools on the East Rand, to ascertain the average number of Grade 2 classes in each school and children in each class. A total of two classes with 24 scholars per school were yielded. These individuals were purposively targeted on the basis that they constitute a representation of the Grade 2 (7-8 year old) elementary male and female school children on the East Rand.

3.5 STUDY SAMPLE AND SIZE

3.5.1 Sampling the schools

Five schools were selected at random; by the method of picking numbers out of a hat, from the private schools listed in Table 3.1. Five schools were selected because of time restraints and availability of fieldworkers and were still deemed enough to obtain a representative sample. Four co-educational schools and one all-female school was sampled.

Table 3.1 Sampling in Independent Schools in the East Rand Districts (Gauteng)

Private (Independent Schools)	Total schools	No of sampled schools
Benoni	8	2
Boksburg	9	2
Germiston	9	0
Kempton Park	3	1
Total	29	5

3.5.2 Sampling the Grade 2 Children

After contact was made with the identified schools, information was given to the headmasters and consent requested from the headmaster or head of the elementary section of the school. The attrition rate of schools was 60%, three out of the five schools that were approached, did not grant permission to conduct the research at their schools. Due to time constraints, the schools were not replaced by new sampled schools. The sampling frame was as follows. One co-education school with three classes, comprising of 65 scholars: 26 male, 39 female children and one all-girls school with 77 female children.

A systematic sampling method was utilised in sampling the Grade 2 children from the class registers at an interval of 2. Every second child on the class register was selected. The starting point was determined by placing a pen at random on each class register, thus selecting 33 children from the co-educational school and 39 from the all-girls school. The total number of the sample prior to parental informed consent was n=72. A high attrition rate continued during this phase, with 24 parents not granting consent for participation and 11 exclusions due to previous remediation and occupational therapy for handwriting, fine motor dexterity difficulties, lost forms and lastly repetition of a grade. The final sample size constituted n=34 children.

The researcher set out to obtain a representative sample, but due to the high attrition rate of schools and children, as well as a fieldworker withdrawing her services, the study sample was smaller.

3.6 SELECTION CRITERIA

The **inclusion criteria** for the children were as follows:

- Children who attended coeducational schools' Grade 2.
- Children participating had to be between 7 and 8years.

The **exclusion criteria** included:

- Formally diagnosed Attention Deficit Hyperactivity Disorder (ADHD) and Attention Deficit Disorder (ADD)
    - Feder & Majnemer (2007) mentioned that sustained attention is necessary to effectively perform handwriting tasks and that children

with ADHD may exhibit handwriting difficulties, characterised by inconsistent letter shapes and sizes.

  - Steger, Imhof, Coutts et al (2001) concluded that 50% of children with ADHD have fine motor coordination problems.

- Pre-term children
  - Feder & Majnemer (2005) conducted a study on handwriting performance in preterm children, compared to term peers at 6 and 7 years old. A decreased sensory awareness of individual fingers, slower speed scores and lower legibility scores in handwriting among the preterm children was found. Preterm children were defined as children with a birthweight < 1250 grams or gestational age < 34 weeks and without major physical and cognitive disabilities. These criteria of Feder & Majnemer (2005) were also used as the exclusion criteria in the study.
- Major physical disabilities affecting the hand, namely,
  - club fingers, amputated digits, juvenile arthritis, arthrogryposis or other congenital/acquired defects.
- Genetic disorders such as
  - Downs syndrome and Fragile X.
- Prenatal exposure to alcohol
- Postnatal events, for example,
  - Head trauma and Infections
- Psychiatric conditions such as
  - Autism (Fuentes, Mostofsky, Bastian, 2009) and Depression

- Children who received previous Occupational Therapy or currently receiving remediation for handwriting or fine dexterity problems.
    - These children that had extra instruction in handwriting and fine motor dexterity were excluded because of this extra tuition affecting the results of the sample when statistical analysis is performed on the testing results.
- Children repeating a grade
    - As repetitive practice and instruction of handwriting and fine dexterity activities will influence the testing results.

3.7 DATA COLLECTION INSTRUMENTS

3.7.1 Questionnaire

The questionnaire consisted of nominal and ordinal measurements and was divided into three sections:

- Demographic data of the parents and children, gestational age, birth weight, occupational therapy referrals (previous or current).
- Devices that are currently in their homes and that are being used by the Grade 2 children (such as, cellular phones, video games, tablet computers, lap top computers, desktop computers) were evaluated in a fixed response table with the option of including other devices not mentioned.
- Frequency of use of each electronic device by Grade 2 children was evaluated in a table. The table consisted of the type of devices on the one axis and the days of the week on the other axis. The frequency of use

was answered in minutes and thus it was possible to calculate the total use per week, total use per day and total use per device per week and day.

- Parental perception of the effect of electronic devices on handwriting was evaluated in a five point Likert scale. The five evaluation categories of the Likert scale were; strongly agree, agree, neutral, strongly disagree, disagree.

3.7.2 Testing/Survey

3.7.2.1 Minnesota Handwriting Assessment (MHA)

The MHA was developed in order to assess the handwriting legibility and speed of first and second grade children. Reisman (1999) had conducted studies that supported the use of the test as a valid screening of handwriting. The inter-rater and intra-rater reliability are both high and furthermore the manual provides excellent guidance, detailed training and scoring practice (Reisman, 1999). The ruler that accompanied the manual provided a guide in the scoring process and thus improved the assessment's quality. The MHA was selected as the evaluation tool for the handwriting, because it is easy to administer and score, give more quantitative results than most handwriting assessments, its strong construct validity and lastly its subjective opinion by teachers as a successful predictor of good and poor handwriting (Reisman, 1999).

The handwriting was scored according to the MHA protocol for scoring. The letters were scored individually based on five categories; legibility, form, alignment, size and spacing. Legibility included that all letters must be present, be lowercase, recognisable out of context and have all the parts complete. If the criteria were not met, all letters were marked incorrect in all five categories. Form criteria included the overall quality of the letters, letters must not have gaps that exceeds one-sixteenth of an inch, letters must not contain extra lines, no sharp points in the curved segments and pointed segments must not be curved. The alignment category criteria states that the letters must rest within one-sixteenth of an inch below or above the baseline. Size category included the following criteria; tops of letters with ascenders within one-sixteenth of an inch of the top solid line, tops of letters without ascenders within one-sixteenth of an inch of the middle dotted line and the bottom of letters with tails should be within one-sixteenth of an inch of the dotted bottom line. Spacing criteria included; letters within the words should not be touching and not be a quarter of an inch apart and the distance between the words should at least be one quarter of an inch in distance. In addition to the 5 qualitative categories, the subjects also received a rate score, earning 1 point for each letter completed within the first 2.5 minutes of the assessment. The 5 qualitative scores combined with the rate score, each of 34 letters can earn up to 6 points. A maximum total score of 204 is possible (Fuentes, Mostofsky & Bastian, 2009).

The MHA also evaluates other aspects of handwriting. The following observations were deemed important in handwriting evaluation and recorded, during the testing of the sample; inappropriate grasp of pencil, frequent adjustment of grasp during writing, poor trunk stability and poor sitting balance. To add to the above observations of handwriting that applied to the research sample, Reisman (1999) also encourage evaluators to be on the lookout for the following additional observations; uncoordinated finger movements, tremors of the hands/fingers, limited movement in the fingers/wrist/elbow, too light/too heavy pencil pressure, the change of hands during the writing task, erasures that create holes in the paper, messy written work, resting head while writing, squints during the writing task and easily distracted when writing.

3.7.2.2 Nine-Hole-Peg-Test (NHPT)

The NHPT has been found to be an effective screening tool for fine motor dexterity in school-age children (Smith & Hong, 2000). The time for the NHPT was recorded with a stopwatch and it was held out of view of the children. The timing started when the first peg was touched by the child and stopped when the last peg was dropped in the container. The time was recorded firstly for the dominant and thereafter the non-dominant hand (Smith and Hong, 2000).

In a normative and validation study of the NHPT with children between the ages of 5 and 10 years the mean completion times for the dominant and non-dominant hand were established for the participants in the USA (Smith & Hong, 2000). The children participating in the normative study was selected from 7 public schools in an urban county in USA, where 11% of the children were left handed and the exclusion criteria included neuromuscular disability, obvious signs of hand dysfunction and with a special education classification (Smith & Hong, 2000). These results, although 15 years old and not conducted on a SA population, will guide as the comparative results for this study. The study of Smith & Hong's (2000) was the first of its kind with an adequate sample size and hence provided descriptive data on fine motor dexterity of children using the NHPT. It also provides occupational therapists, hand therapists and teachers with a baseline to compare results for evaluating, screening and treating elementary school children with fine motor dexterity problems.

3.8 PILOT

A pilot study of the questionnaire was performed in two different phases. In phase one the content validity of the questionnaire was assured through an appraisal conducted by two identified experts in the field of research methodology, occupational therapy and hand rehabilitation. In phase 2 the pilot study of the questionnaire was conducted; where the questionnaire was completed by a sample of 3 parents from the selected schools, who were subsequently excluded from the study.

This validity testing and piloting of the instrument served the following objectives:

- to extract new content areas that might have been overlooked;
- to assess the internal consistency of items constructed; and
- to implement any changes in questionnaire design that might be deemed necessary.

A pilot study of the testing procedures was conducted; where three Grade 2 children were tested. The testing was done in a classroom with the same chairs, desks and writing utensils. Thus consistency in the testing environment and wording of the instructions was rehearsed. Informed consent was obtained from the parents and written assent from the children, prior to the pilot study.

The pilot study assisted in determining any problems in the fieldwork design. The fieldworker had been trained prior to the pilot study in the use of the MHA and NHPT tests, wording of the instructions, reading of the MHA manual, practising on the examples of the MHA's marking sheets, marking of the MHA scoring sheets, consistency of instructions provided, desired seating position and class room environment consistency. During the pilot study intra-rater reliability was established for the MHA scoring and subsequently the handwriting sheets were marked a second time, 3 weeks after the pilot assessment had been conducted. A number of discrepancies were corrected after comparisons of specific letters were made to the MHA manual. The fieldworker received additional training and evaluation instruction with the use of the MHA examples and quick references. The fieldworker was a private tutor for elementary school children with 3 years' experience from Grade 1 to Grade 3. With her experience in Grade 2 tuition and marking of handwriting, she was deemed the most qualified to administer and assess the handwriting.

Changes enforced after the pilot study included further training in the wording of the instructions for the MHA and the NHPT. Challenges with regards to the NHPT were observed; the pegs on occasion were bumped out of the container and the pilot sample also took two pegs at a time. After discussion with the research team, it was decided that the researcher will put the pegs back into the container to save time and thus the child will not have to search on the ground for the lost pegs. Clear instruction prior to the NHPT, about taking one peg at a time will also be given.

3.9 DATA COLLECTION AND PROCEDURES

3.9.1 Consultation Phase

A visit to an electronic shop on the East Rand was used to ascertain which electronic devices are frequently used by Grade 2 (7-8years old) children and this informed the questionnaire design. The following electronic devices were most frequently utilised by 7 to 8 year old children, according to the experts in the electronic shops; tablet computers, video games, cellular phones and computers.

3.9.2 Parent Questionnaire

The self-administered questionnaire, together with a covering letter was sent to the parents/primary caregiver, of the grade 2 children at the selected schools. The covering letter included a request for the return of the questionnaire and informed consent form within two weeks. The class teacher collected the returned documents and returned them to the researcher.

3.9.3 The Minnesota Handwriting Assessment

A suitable and convenient time was negotiated with the principle/head of the elementary school and teachers before class entry. A brief and age-appropriate explanation of the study was offered to the selected grade 2 learners, with parental informed consent and who complied with all the inclusion criteria, before initiation. Written assent was obtained from the participating children.

The test was administered to the participants in their own class and at their own desk and chair. The MHA was administered to the entire class at the same time.

Extrinsic environmental and biomechanical seating factors was evaluated and adjusted where necessary before the testing was commenced. Feder & Majnemer (2007) have noted important extrinsic factors that can affect handwriting performance. They include sitting position, chair/desk height, writing instrument, type of paper used, paper's placement on the desk, environmental lighting and noise. It is recommended that the children should be seated with their feet flat on the floor, hips and knees at a 90 degree angle, back supported against the chair back, elbows slightly flexed and the forearms resting comfortably on the desk surface (Feder & Majnemer, 2007). Similar test sheets and HB pencils were supplied to the children for completion of the test. The fieldworker was present with the researcher in the classroom to assist with queries and incorrect seating. The MHA presented a sample of the following words: "The brown jumped lazy fox quick dogs over". The children were instructed to copy the words on the provided solid lines (baselines) on the lower half of the test sheet, making their letters the same size as the sample and using their best handwriting. The test sheets were scored according to the scoring method previously described. The researcher and fieldworker made observations and field notes around faulty trunk stability, seating balance, undesired pencil grips and repeated changes in pencil position.

3.9.4 The Nine-Hole-Peg-Test

After the MHA, the researcher provided the verbal instructions for the NHPT, while demonstrating the expected behaviour to the subjects. The pegboard was positioned in front of the researcher/fieldworker's body as they prepared to model the same hand that is being tested on the student. The researcher said, "The hand you write with (dominant) does all the work while the other hand (non-dominant) holds onto the pegboard. Pick up the pegs one at a time as fast as you can and put them in the holes in any order. You can start from any hole. After you put them all in, then you take them out, one at a time as fast as you can and put them back in the container. Now watch me do it." (Smith & Hong, 2000). After the verbal directions were completed the demonstration began, putting all nine pegs in and out as fast as possible.

The researcher repositioned the pegboard in front of the subject with the container/pegs close to the dominant hand, while the non-dominant hand holds on to the other end of the pegboard. A practice round was allowed. Thereafter the subject was instructed "this will be the real test with the same hand, don't touch a peg until I say go. Are you ready? Go!" The researcher held the stopwatch out of view of the subjects, timing started when the first peg was touched and stopped when the last peg is dropped in the container. The time was recorded (Smith & Hong, 2000). The test was repeated for the non-dominant hand. The grasping of the pegs can be a challenge, but the researcher/fieldworkers quickly retrieved the loose peg or replaced it with a spare peg prior to the container becoming empty, to avoid stopping the test. Conversation was limited to the occasional positive feedback and correction "good job and don't use the other hand". The testing took 3-5 minutes for each subject.

3.10 DATA MANAGEMENT

Data from the questionnaires and test results was electronically captured and stored on a hard drive. Back-ups were made, by the researcher, on a portable hard drive and the data password protected to assure the data security. The research data will be kept for a minimum period of at least five years in a secure location arrangement by the supervisors.

3.11 DATA ANALYSIS

Data obtained from the questionnaires and testing was captured in an excel spreadsheet. The IBM SPSS version 22 was used to analyse the data (IBM Corporation, 2012). A p value <0.05 was considered as statistically significant. Non parametric tests were done since most continuous measures were not normally distributed. Mann Whitney tests were used to compare medians between two groups, Fischer's exact tests were used to compare proportions between two groups, and Spearman's rank correlation was used to compute correlation coefficients between two variables. The Yes/No fixed responses and Likert scale questions in the questionnaire were analysed by the use of descriptive statistics, such as frequency counts and percentage tables. Continuous variables were summarized using mean, standard deviation and range (minimum-maximum). Box plots were employed to graphically summarise continuous variables.

3.12 RELIABILITY AND VALIDITY

The reliability and validity of the questionnaire, MHA and the NHPT will be discussed in the following section.

3.12.1 Questionnaire

Content validity of the questionnaire was assured through an appraisal conducted by two identified experts in the field of research methodology, occupational therapy and hand rehabilitation. Changes were made after the appraisal and included additional space for other electronic devices that participants could have at home and the omission of race in the demographic data.

3.12.2 Minnesota Handwriting Assessment

The content validity has been established by Reisman (1999). Evaluating the handwriting legibility, form, alignment, size, rate and spacing makes it a comprehensive evaluation measure and the sentence that was copied contains all the alphabetical letters. Reisman (1999) established content validity. The inter-rater reliability was tested with the use of Pearson correlation and ranged by category for two experienced scores. The results ranged from .90 for Form to .99 for Alignment and Size. Between an experienced and inexperience scorer the inter-rater reliability ranged from .87 for Form to .98 for Alignment and Size. The intra-rater reliability between two experienced scorers and an inexperienced scorer resulted in the following correlation scores. Rate 1.00, legibility .96, form .97, alignment .99, size .99 and spacing .97. For these reasons, the MHA was selected and used to ascertain the handwriting legibility and speed of the Grade 2 sampled research participants.

The reliability of the MHA had been improved by the use of the same writing utensils, chair and desks, similar external environment in one class room and during the same time period in the year, within the same week and same time of the day. The same verbal instructions were given to all the participants before the commencement of the test.

3.12.3 Nine-Hole-Peg-Test

A test-retest reliability (rs=.81 and .79) can be concluded as moderately high and (rs.=99) as a high inter-rater agreement was obtained (Smith and Hong, 2000). The NHPT has adequate concurrent validity of all tested ages with correlations of – 0.80 and -0.74 between scores of the NHPT and the Purdue Pegboard Test. Both tests are standardised fine motor dexterity tests and thus validated the NHPT for the purpose of testing the research participants in this study. Construct validity has been established by the significant difference in the test scores between special and regular education groups (Smith & Hong, 2000).

The reliability of the Nine-hole peg test had been improved by giving the same verbal commands to the subjects, the researcher and fieldworkers demonstrated the test physically to each subject on the left and right hand before the subject were asked to complete the test, each subject received one test run and during this practise run any errors in seating position, placement of hands/peg board/trick movements were corrected by the researcher and fieldworkers.

3.13 ETHICAL CONSIDERATIONS

Data collection commenced after ethical clearance had been obtained from the Biomedical Research Ethical Committee (BREC) of the University of KwaZulu-Natal with the following reference number, BE292/14. Permission was obtained from the GDE, principal and the head of the elementary department from each school, prior to school entry.

Mack, Woodsong, MacQueen et al (2005) mentioned that the core ethical principles in research include: Respect for persons, beneficence and justice; subsequently these principles served as the core of this research report.

Respect for persons was maintained by obtaining informed consent from the parents/ primary caregivers and written assent from the children before the survey testing was conducted. The informed consent documents included the purpose of the study, what it is going to be used for, what the possible benefits for the participants are, what was expected of the participant and how confidentiality will be maintained (Mack et al, 2005).

Confidentiality was maintained by not asking for personal details on the survey and questionnaires, as a code number was allocated to each participant according to class lists and the parental questionnaire code matched the child's number. Confidentiality was also assured by not using any participants' or school name in the thesis and discussion. The Grade 2 children and their parents were informed that although the data will be published in a research report, they will remain anonymous and that they were free to withdraw from the study at any time.

A hand exercise gift and information regarding the types of video games that are age appropriate served as beneficence to the children. Feedback meetings were conducted in order to disseminate the research results and where the principals, teachers, parents and children were invited. Written research results will be disseminated to the Department of Basic Education, GDE and ISASA.

Non-maleficence was assured by; requesting the research participants to complete tests that were not harmful to them, no procedures which may have unpleasant or harmful side effects were conducted, they did not commit an act which diminished their self-respect or cause them to experience shame, embarrassment or regret. The survey tests were conducted in the Grade 2 classrooms and this also assured a familiar environment that was not stressful or unpleasant.

Minimal absence from the classroom and disruption in the normal school programme was assured by testing in a suitable time, arranged prior to testing and for a total period of 20 minutes for each class. The smaller sample size helped in this regard, with minimal time taken out of the school day.

The primary data will be stored for a period of five years, in the department, to ensure the integrity and safety of the data set. The researcher took clear and accurate records of all the ethical procedures adhered to during the research process in order to demonstrate that the accurate research procedures had been followed.

3.14 SUMMARY

The purposive systematic sampling methods guided the sampling methodology for this quantitative correlational research study. Sadly the high attrition rate affected the sample size, but in retrospect aided the quality of the fine motor dexterity and handwriting assessments/scoring. Ethical principles were ensured with the use of; informed consent documents for the principals/head of elementary department, parental cover letters and informed consent documents and lastly, the Grade 2 assent forms completed prior to the testing.

CHAPTER 4

RESULTS

4.1 INTRODUCTION

The purpose of this research was to determine the handwriting and dexterity children in Grade 2 elementary school children and to determine whether a correlation exists between electronic device type and frequency of use; and fine motor dexterity and handwriting. The results will be discussed under the following headings; demographic data, types of electronic devices, frequency of electronic device use, dexterity, handwriting, gender correlations and differentials and correlations.

4.2 DEMOGRAPHIC DATA

Seventy seven children were selected for participation, n=34 children who met all of the inclusion criteria and whose parents had given consent to participate, were included in the final sample. With regards to the gender of the children 23.5% (n=8) were males and 76.5% (n=26) were females. The children in this study had a mean age of 93.2 months (7.8 years), the youngest 86 months (7.2 years) and the oldest 97 months (8.1 years). Handedness among the children was calculated and 11.8% (4) were left hand dominant and 88.2% (30) were right hand dominant.

The researcher in this tabulation below endeavours to state clearly what objectives should be investigated further in this results chapter.

Table 4.1 Objective and the methods used to ascertain the results

Objective		Method
1	To describe the type and frequency of electronic devices used by the children.	Questionnaire
2	To measure the children's fine motor dexterity of the dominant hand and non-dominant hand.	Nine-Hole-Peg-Test (NHPT)
3	To measure the children's handwriting.	Minnesota Handwriting Assessment (MHA)
4	To determine any gender differences in electronic device use, fine motor dexterity and handwriting.	Independent Samples Mann Whitney U Test
5	To determine to what extent the handwriting and fine motor dexterity are affected by the type and frequency of electronic devices.	Spearman's Rank correlation

4.3 TYPE OF ELECTRONIC DEVICES

The tabulation below identifies the types of electronic devices used and the combined percentage of use per device type per week.

Table 4.2 Type of electronic devices used

Cellular phone	Touch screen	76.5%	94.1%
	Manual typing	17.7%	
Tablet	Standard size	52.9%	88.2%
	Mini	35.3%	
Video Games	Console	41.2%	76.5%
	Handheld	35.3%	
Computer	Desktop	29.4%	73.5%
	Laptop	44.1%	
Other	Leapfrog	11.8%	11.8%

When the devices were grouped together, it was clear that cellular phones were most frequently used at 94.1%, with the touch screen cellular phone (smartphone) owned and utilised more than manual phones. Tablet computers are the second most frequently used at 88.2%.

4.4 FREQUENCY OF ELECTRONIC DEVICE USAGE

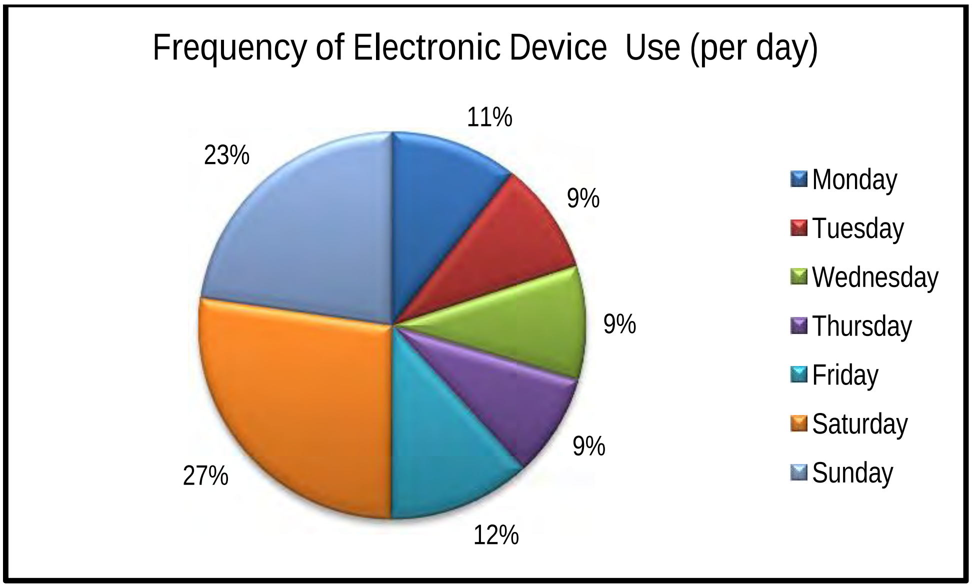

Figure 4.1 Frequency of use distribution per day of the week

Usage of electronic devices over the weekend (Saturday and Sunday) exceeded the amount of time in the weekdays, by more than double.

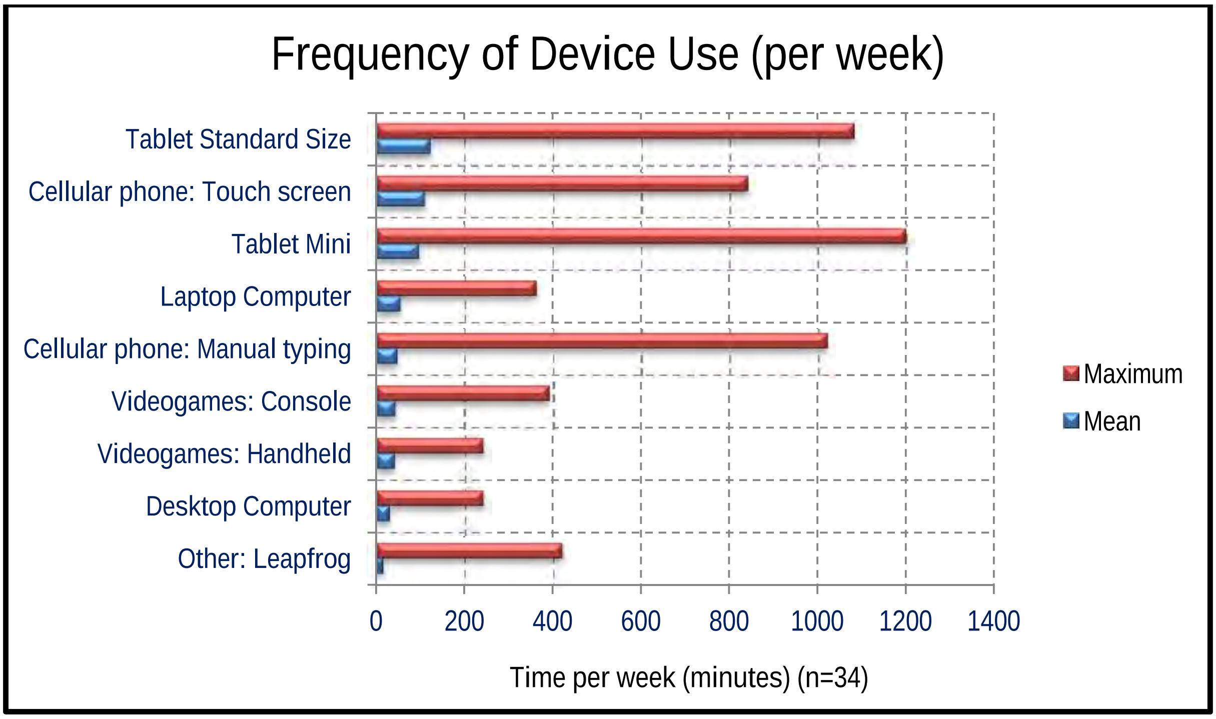

Figure 4.2 Mean/Maximum of electronic device's usage per device type per week

Figure 4.2 represents the average/mean and maximum weekly usage per device type and the results will now be mentioned. The frequency of usage for the specifically selected electronic devices for a week cycle was calculated. The mean and maximum calculations for nine different devices; the standard tablet computer, the mini tablet computer, desktop computer, laptop computer, console video games, handheld video games, touch screen cellular phone (smartphones), manual type cellular phone and the leapfrog device.

4.5 DEXTERITY

The NHPT was used to measure dexterity for the dominant and non- dominant hand in the children.

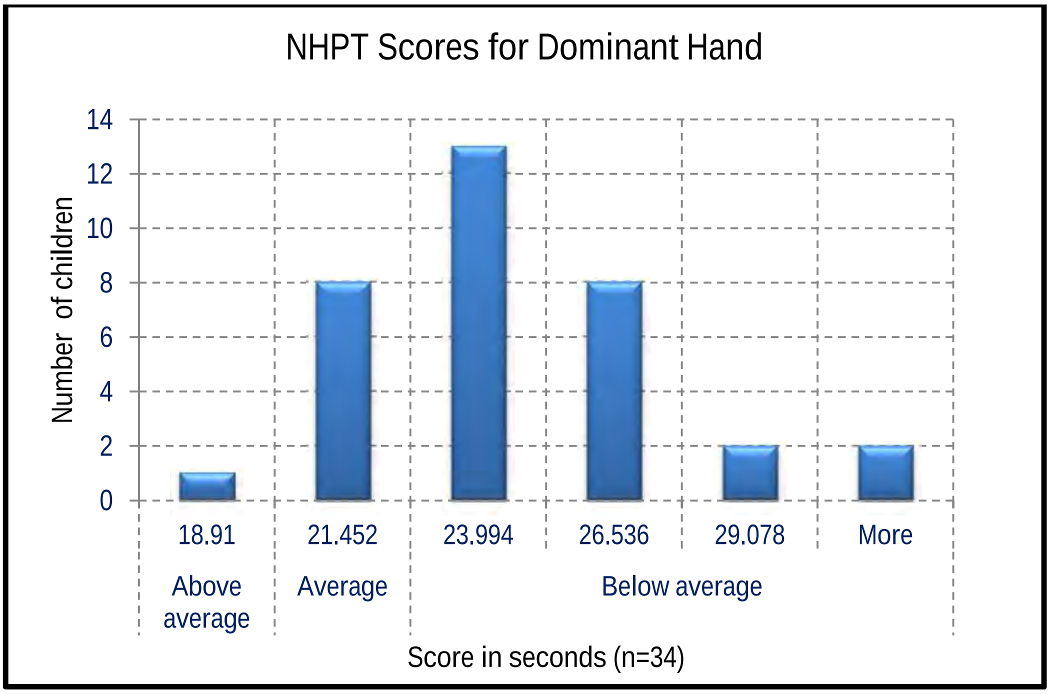

Figure 4.3 Average time (seconds) to complete the NHPT dominant hand

Figure 4.3 illustrates the average results of the NHPT for the dominant hand of both the male and female children together. The completion time was normally distributed throughout the sample of 34 participants, with a mean score of 23.22 seconds, a minimum of 18.91 seconds and lastly a maximum of 31.62 seconds. Gender differentials for the NHPT results on the dominant hand revealed the following. The female children's scores had a mean of 22.98 seconds and the male children's scores had a mean of 24.00 seconds.

In Figure 4.3 eight children displayed average and one above average dexterity scores that compares to the average in the standardised scores below the norm of 21 seconds. The remaining 25 children displayed below average scores in dexterity compared to standardised scores.

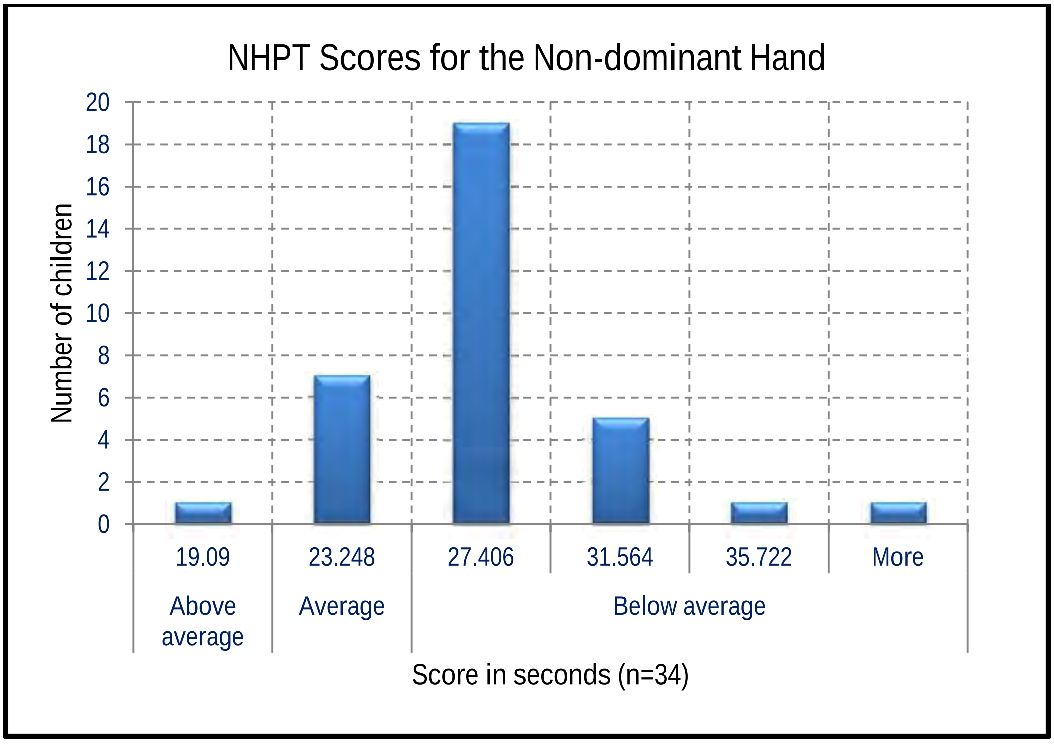

Figure 4.4 Average time (seconds) to complete NHPT non-dominant hand

Figure 4.4 illustrates the average results of the NHPT for the non-dominant hand for both the male and female children together. The completion time was normally distributed throughout the sample of 34 participants, with a mean score of 25.74 seconds, a minimum of 19.09 seconds and lastly a maximum of 39.88 seconds. Gender differentials for the NHPT results on the non-dominant hand revealed the following. The female children's scores had a mean of 25.15 seconds and the male children's scores had a mean of 27.67 seconds. In Figure 4.4 seven children displayed average and one above average dexterity scores compared to the average in the standardised scores, below the norm of 24 seconds. The remaining 26 children displayed below average scores in dexterity compared to standardised scores.

4.6 HANDWRITING

In the tabulation below the handwriting results of the female and male children are displayed.

Table 4.3 Average female and male MHA results

Minnesota Handwriting Assessment Categories	Total participants	Scoring category (Performance)	Female	Scoring category (Performance)	Male	Scoring category (Performance)
HANDWRITING TOTAL	183.7	Like peers	181.7	Somewhat below peers	190.1	Like peers
LEGIBILITY	33.7	Like peers	33.7	Like peers	33.6	Like peers
FORM	32.3	Like peers	33.5	Like peers	28.4	Somewhat below peers
ALIGNMENT	32.2	Like peers	32.6	Like peers	30.6	Like peers
SIZE	23.8	Somewhat below peers	21.5	Somewhat below peers	30.9	Like peers
SPACING	32.2	Like peers	32.5	Like peers	31.3	Somewhat below peers
RATE/SPEED	26.3	Somewhat below peers	24.5	Somewhat below peers	32.1	Like peers

A standardised assessment scoring sheet accompanied the MHA and the results for each child can fall in one of the following three categories; performing like peers, performing somewhat below peers and performing well below peers. Each sub-category that formed part of the total handwriting score have standardised numeric scores that places the child in this final category. Further, differentiation was made between the months of year when the testing was conducted in. To this end, the scoring sheet has different scores for testing done in February than

December. This makes provision for the stage of handwriting tuition in the school curriculum. The standardised scoring sheet for each category of the testing was added to the Appendices section, Table 2. The results also displayed in Table 4.5 were as follows.

The average total handwriting displayed the following results, the 34 children scored, “Performing like peers”, the male children “Performed like peers” and the female children “Somewhat below peers”.

4.6.1 Handwriting observational faults

The MHA also evaluates other aspects of handwriting. The following observations were made and recorded, during the testing of the sample such as inappropriate grasp of pencil, frequent adjustment of grasp during writing, poor trunk stability and poor sitting balance. A total of 16 participants had a faulty pencil grip with 12 being female and 4 male. The frequent adjustment of the pencil grip was observed in 4 participants, 3 female and 1 male. Weak trunk stability was observed only in 5 female children and 2 male children and 1 participant had a sitting balance fault.

4.7 GENDER CORRELATIONS AND DIFFERENTIALS

The non-parametric Mann Whitney test was utilised to compare the medians between two groups at a significance level of p=0.05 and the Fisher’s exact test was used to compare proportions between two groups. The comparisons between the child’s gender and types of electronic devices, total electronic device use, dexterity, handwriting, dexterity and handwriting is presented.

4.7.1 Association between Gender and Types of electronic devices

The type of electronic devices used and the gender differentials revealed no statistical significance, for the standard tablet (p=1), mini tablet (p=1), desktop computer (p=1), laptop computer (p=0.257), console video games (p=0.228), touch screen cellular phone (p=0.355) and the manual type cellular phone (p=0.609) and the null hypothesis was accepted for no statistical significant difference in electronic type use. Significance was established for handheld video game (p=0.001) use, where the male use was greater than the female children and here the null hypothesis was rejected.

4.7.2 Gender and Total electronic device use

No significant difference in the total electronic device use averages of male and females (p=0.413) were established, thus the null hypothesis was accepted.

4.7.3 Association between Gender and Dexterity

Gender differentials in the fine motor dexterity ability of the dominant and non-dominant hands revealed no significant difference, when comparing the medians of male and female children. No statistical significance was noted when comparing gender differences against dexterity of the dominant (p=0.647) and non-dominant hands (p=0.485). In the gender difference for dexterity, the null hypothesis was accepted.

4.7.4 Association between Gender and Handwriting

A mean total handwriting score of 190.1 for the males and a total of 181.7 for the females out of a possible 204 points possible were obtained as can be observed in Table 4.3. The male children thus out-performed the female children in the total handwriting assessment. The total handwriting score revealed no significant difference (p=0.152) and the null hypothesis was accepted.

4.7.5 Association between Gender and Dexterity and Handwriting

Correlations between the dexterity and handwriting average scores were performed. The children's dexterity and handwriting for the dominant hand, showed a significant but weak negative correlation for females with (rho= -0.465). It is important to note the slower time in the NHPT, the faster the dexterity of the child. In this regard, the slower the dexterity of the females dominant hand (writing hand) the lower the handwriting scores. The less time taken in the NHPT results in more advance dexterity and thus correlates with an improved handwriting. In the non-dominant hand significant but weak negative correlations exists for both males (rho= -0.563) and females (rho= -0.492). In this instance for this association, the null hypothesis was rejected.

4.7.6 Association between Gender and Sub-categories of Handwriting

The handwriting sub-categories were analysed for gender differentials and revealed the following results. A high significance was established for the speed/rate and form of handwriting between the medians of male and females. The male children scoring higher than females for rate (p=0.015), here the null hypothesis was accepted and females scoring higher for form than males with (p=0.005) and here the null hypothesis was rejected.

In the other categories of handwriting the males outscored the females in; total score (p=0.152) and size (p=0.058) thus the null hypothesis was accepted. In the following sub-categories the females achieved higher scores; legibility (p=1), alignment (p=0.141), and spacing (p=0.327) and the null hypothesis rejected.

4.7.7 Association between Gender, Subcategories of Handwriting and Dexterity

Correlations for gender differentials between the handwriting category scores and fine motor dexterity for the dominant hand revealed some important correlations for the male children, but not statistically significant due to the small sample size. In the female children form and size were negatively correlated with the dominant hands' NHPT dexterity score with form (rho= -0.519) and size (rho= -0.648) thus the null hypothesis was rejected. For the non-dominant hand some correlations were important for males but not statistically significant due to the small sample size. In the female children the handwriting's size was negatively correlated with the dexterity (rho= -0.626) and here the null hypothesis was also rejected.

4.8 CORRELATIONS

4.8.1 Correlation between Total device use and Dexterity

No correlation was established between the fine motor dexterity in the dominant hand compared to the total electronic device usage per week (p=0.974). In answering the correlational objective it is stated that no correlation exists between total time spent on electronic devices per week and the dominant hands' dexterity.

Correlations between the total electronic device use and fine motor dexterity for the non-dominant hand showed a very weak positive correlation (rho= 0.137) as can be observed in figure 4.5. An increase in electronic device use thus leads to longer time taken to complete the NHPT with poorer dexterity as a result and thus the null hypothesis is accepted for the non-dominant hands' dexterity.

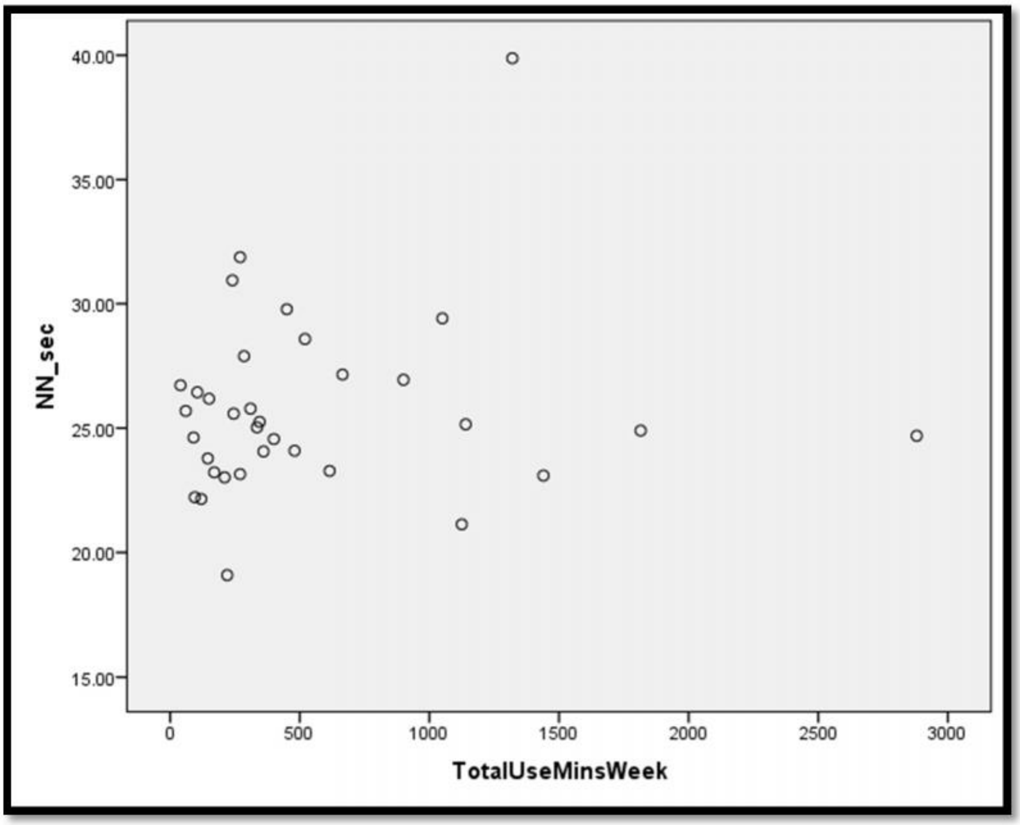

Figure 4.5 Total device use and non-dominant hands' dexterity correlation

4.8.2 Correlation between Total device use and Handwriting

The correlations between the total electronic device use and handwriting total score resulted in a weak positive correlation of (rho =0.110), as can be observed in Figure 4.6 and the null hypothesis is rejected.

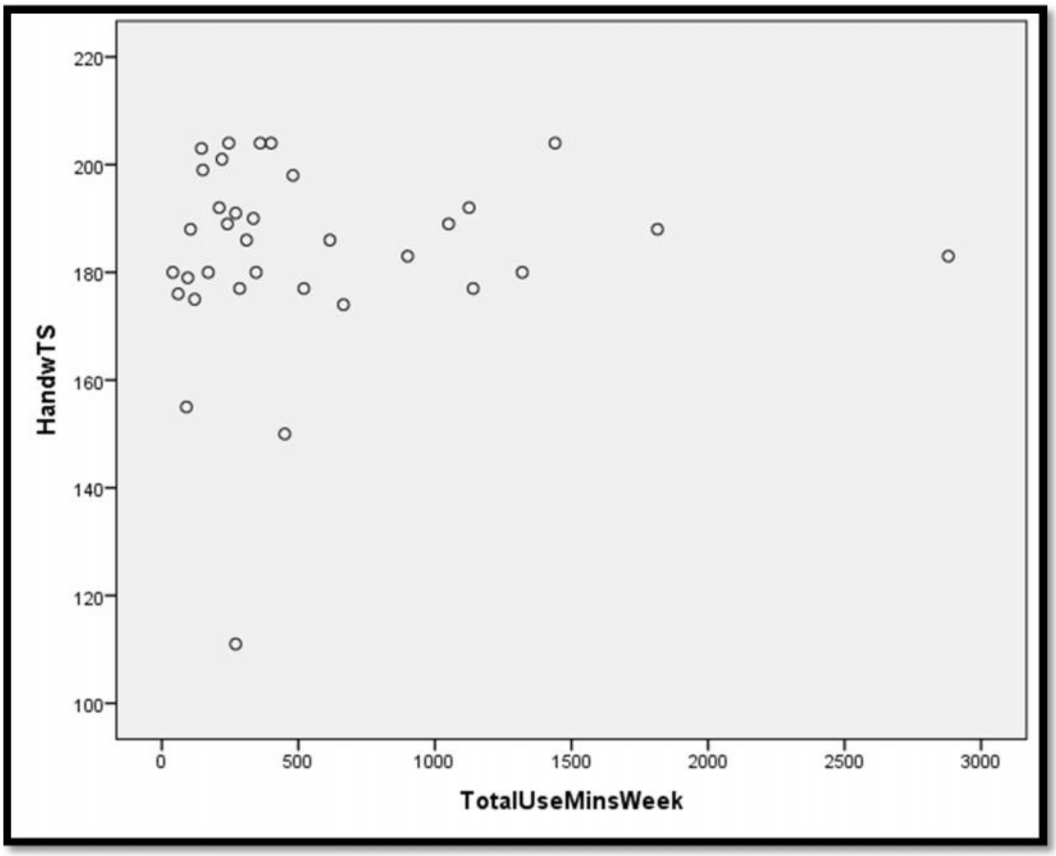

Figure 4.6 Total electronic device usage per week (minutes) to the total handwriting score of the MHA

4.8.3 Correlation between Total device use and Handwriting sub-categories

Correlations between the total electronic device use and the sub-categories of handwriting revealed a weak positive correlation for legibility (rho =0.105), a weak positive correlation (rho=0.141) for alignment, a weak positive correlation for the rate/speed scores with (rho=0.214) and for the above mentioned sub-categories the null hypothesis was rejected, where the weak negative correlation (rho= -0.141) for form resulted in accepting the null hypothesis.

No correlation was measured between the total electronic device use and spacing (rho=-0.044) and size (rho=-0.005) scores.

4.8.4 Correlation between Total handwriting score and faulty observations

The total handwriting scores were correlated to all measured handwriting observational faults and the results were as follows.

No statistical significant correlations were measured when correlated to the MHA total score; for the pencil grip fault (p=0.798), the weak trunk stability (p=0.151), poor sitting balance (p=0.118) and frequently adjustment of the pencil grip (p=0.925) and the null hypothesis accepted.

4.8.5 Correlation between Handwriting sub-categories and faulty observations

The handwriting subcategory scores were correlated to all measured handwriting observational faults and the results were as follows. For the pencil grip fault, no statistical significant correlations were found between the sub-categories of handwriting; speed (p=0.102), legibility (p=0.175), form (p=0.932), alignment (p=0.670), size (p=0.506) and spacing (p=1) and the null hypothesis was accepted. For weak trunk stability, no statistical significant correlations were found between the sub-categories of handwriting; legibility (p=0.647), form (p=0.452), alignment (p=0.934), size (p=0.934) and spacing (p=452) and the null hypothesis was accepted. There was a statistical significant correlation found between the speed of the children's handwriting and those with and without faulty trunk stability (p=0.007) and the null hypothesis was rejected. For poor sitting balance during the writing test, no statistical significant correlations were found between the sub-categories of handwriting; speed (p=0.412), legibility (p=0.765), form (p=0.588), alignment (p=0.588), size (p=0.412) and spacing (p=706) and the null hypothesis was accepted. For adjusting the pencil grip during the writing assessment, no statistical significant correlations were found between the sub-categories of handwriting; speed (p=0.741), legibility (p=0.295), form (p=0.539), alignment (p=0.814), size (p=0.671) and spacing (p=571) and the null hypothesis was accepted.

4.9 SUMMARY

This chapter described the results of this study against objectives of this study. Correlations between gender, handwriting scores and dexterity were computed with either acceptance or rejection of the null hypothesis. The null hypothesis was rejected in the following correlations; the males used handheld video games more frequently than females, the female's handwriting total was higher with an improved dominant hand dexterity and the same was seen in both males and females' non-dominant hands' dexterity. The null hypothesis was rejected in the correlation between the total electronic device use and the total handwriting score as well as the correlation between the speed of handwriting with a poor trunk stability. The discussion chapter will give an overview of the results obtained in Chapter 4.

CHAPTER 5

DISCUSSION

5.1 INTRODUCTION

The following discussion will frame the results within the context of available research. The following headings will structure this chapter; handwriting at the foundation phase, discussion of device use, handwriting and fine motor dexterity covering the frequency of electronic device use, electronic device types, dominant and non-dominant hand dexterity, handwriting dexterity and handwriting. Gender differentials, correlations and a summary will conclude the discussion.

5.2 HANDWRITING AT THE FOUNDATION PHASE

Handwriting remains the predominant task in the first three grades of the elementary school programme and amounts to more than fifty percent of time a day spent on handwriting and fine motor dexterity instruction in the classroom (Tseng et al, 2000). The correct handwriting instruction is only one external factor that influences handwriting at the foundation phase schooling level, with the other factors including writing instruments and material used, sufficient time and the quality of handwriting practice undertaken. In this regard, children are increasingly being entertained by electronic devices and the media. This is supported by market research conducted in SA in older children (Pew Research Centre, 2014) and in seven to eight year olds in the USA (Common sense media, 2013). Straker et al (2008) voiced concern over promoting the use of electronic devices such as tablet computers, which are being incorporated as a learning aid in some elementary school setups, without knowing their physical impact on children. This increased presence of electronic devices in the children's lives, increases the time spend on these devices a day and can affect the amount of time spent on practising handwriting skill at school and recreationally at home. For this reason, the study was undertaken to gain an insight into the type and frequency of electronic device usage in a SA context and correlate the use to handwriting and handwriting dexterity, and ascertain any connection to device use and the quality of handwriting. There's a plea from authors (Wartella, Vanderwater & Rideout, 2005) to conduct research to gain an improved understanding how young children use new media. The following discussion will provide an overview of the results obtained in order to answer the above call as well as answer the objectives of the study.

A high attrition rate influenced the sample size in two distinct areas; the schools and the children participating in the study. Three out of the five sampled schools did not grant permission to conduct research at their institution and only thirty-four out of seventy-seven children met the inclusion criteria. The reasons for exclusion of the children included the following; twenty-four parents did not grant written consent, eleven children received previous remediation and/or occupational therapy for handwriting problems, fine motor dexterity difficulties and the remaining children had either repeated a grade or had not returned the forms. As a result of the high attrition rate, there was a lower percentage of male children participating in this study.

5.3 DEVICE USE, HANDWRITING AND FINE MOTOR DEXTERITY

The following section will be dedicated to discussing the objectives of the study and relating them to relevant literature. Firstly the frequency and type of electronic device use, secondly dexterity and handwriting of the children followed by gender differentials and lastly the correlation between electronic device use, handwriting and dexterity will be discussed.

5.3.1 Frequency of electronic device use

In achieving the first objective, of determining the children's frequency of electronic device use and choice of device, a comprehensive literature search was conducted, with no available literature been sourced on electronic device usage in seven and eight year old SA children. As far as the researcher is aware, this study provides the first data on Grade 2's (age 7-8 year old) electronic device type and frequency usage in the SA context.

Frequent electronic device use is posited by Bryant et al (2010) to alter the recreational activities of children and this was evident in the nine hours of device usage per week, with the majority of this time being spent during the weekend. On average, devices were used for 2.5 hours on a Saturday and 2 hours on a Sunday. In a school week, children's time is devoted to formal education, handwriting instruction and extramural activities and it is over the weekends where the children are deemed to have more time to experiment, develop through play and exploring the environment and for this reason the frequent device usage over weekends are of great concern.

Common sense media (2013) reported the usage of electronic media devices for 0 to 8 year old children and revealed a daily average use of mobile devices that has tripled from 5 minutes to 15 minutes over the last two years from 2011 till 2013 where an average of 17 minutes a day was spent on using a computer, 14 minutes a day using a console or handheld videogame player, 5 minutes using a cellular phone, video iPod and iPad (Common Sense Media, 2013). Comparing the above USA daily usage of mobile devices, this study had an average of 17 minutes of tablet computer use, the touch screen cellular phone (smartphones) had an average of 16 minutes and lastly the mini tablet had an average of 14 minutes use per day. When the mini tablet, standard tablet and touch screen cellular phones were grouped together under mobile devices, an average of 47 minutes use a day was the result, where this data is considerably more than the 15 minutes of mobile devices use by the USA children, per day. The console and handheld videogame use in this study had an average of 6 minutes per day and this is almost half the amount of USA children that played 14 minutes per day.

The easy accessibility and the popularity of these mobile devices for children's entertainment are provided as the reason for the increase in frequency of use. To further explain the popularity of mobile devices and the games children play on them, Von Salisch & Oppl (2006) was of the opinion that children select their leisure activities, because it addresses a task that challenges their development and they are motivated to resolve. They further speculate that school children may spend hours playing games due to a desire to hone fine motor skills and be an expert in the game.

5.3.2 Electronic device types

Favourite types of devices used by both male and female children included touch screen (smartphone) cellular phones, mini tablet computers and standard size tablet computers. These three devices are grouped under mobile devices and the accessibility of mobile devices, once again is posited as a reason for its popularity in children because of the internet access where games can be downloaded and played on these devices. According to Pew Research Centre (2014), 91% of SA's own a cellular phone, with 33% owning smart phones rather than the manual type cellular phone. The population that owns these smartphones are predominantly under the age of 30 years and in the light of the report, parents of 0 and 8 years old children will rather own a smartphone than the older manual type phone. The accessibility of the smartphone for children's use is thus increased and this was seen where smartphone cellular phones were among the highest types of devices used by 76.5% of the children, 17.7% used manual cellular phones and this amounted to a total of 94.1% of cellular phone usage, evidently the most popular device in the study.

Videogames use was classified under the fourth (console videogames) and fifth (handheld videogames) most popular device and the male children used handheld videogames significantly more that the females. Bryant et al (2010) voiced their concern that the majority of the gaming equipment is not designed for young children but rather for an older target audience and once the game system enter into a household the children also use it. Many of the devices that surround the young people in the society were not intended for their use (Bryant et al, 2010) due to the smaller hand size of children. The numbers of specifically designed video games for preschool children are increasing, but are still limited. During certain console video games, the hand use during its play with the large controllers, is positioned to incorporate a different hand function than normal recreational activities, for example, cutting, drawing and play with play-dough, that incorporates more fine motor and intrinsic hand function. Bryant et al (2010) considered the relationship between common household media devices and the fine motor skills that are required for their use and found that the Nintendo DS and other handheld devices require recruitment of fine motor skills for usage and manipulation. In contrast the Nintendo Wii requires broader movements involving primary gross motor skills.

Mobile electronic device use incorporates predominantly fine motor skills in its operation and play, which is evident from the intricate finger movement required in its operation. Further, the use of these devices was expected to improve the fine motor dexterity scores when considering the finger exercise during its use, but this was not the case in the resulting dexterity scores of the participating children. This is discussed further below.

5.3.3 Dominant and non-dominant hand dexterity

Male and female children had consistently weaker dexterity scores than the standardised research scores to which they were compared against (Smith & Hong, 2000; Wang et al, 2011). The dominant hands' dexterity results were between one and three seconds slower, where the discrepancy was less for the non-dominant hands' result with one to two seconds difference.

A study conducted by Wang et al (2011) on the assessment of dexterity function used a convenient sample of individuals between the ages of 3 and 45 years old. The average scores for right hand fine dexterity measured with the NHPT were 19.9 for the ages of 7 to 9 years old and the dominant hand's dexterity was also below 20 seconds. The left hands' (mostly the non-dominant hand) mean score was 20.7. A comparison of the average results between Smith & Hong (2000) and

Wang et al (2011) revealed very similar dexterity results, taking into consideration a time lapse of 11 years. Notwithstanding this, it is clear that the average scores from this research study were higher when compared to the other studies with weaker dexterity being displayed.

With regards to the fine motor dexterity scores in this research study, the male children scored consistently slower completion times than the female children, on both the dominant and non-dominant hand during the NHPT. This is consistent with the results of Smith & Hong (2000), where females displayed superior dexterity from the age of 5 to 8/9 years old for the dominant hand and from the age of 5 to 8 years old for the non-dominant hand. From the ages of 9-10 years old it appears that the difference in fine motor dexterity speeds among genders equals out and the margin of difference is very small or in the dominant hand scores, with the male children started displaying faster hand dexterity scores (Wang et al, 2011).

Taking into consideration the relatively slow dexterity scores, it is evident that mobile devices usage does not guarantee improved dexterity in children. Hand development at the foundation phase is crucial (Henderson & Pehoski, 2006) and other recreational activities children busy themselves with from early childhood is still deemed imperative for adequate hand dexterity.

5.3.4 Handwriting dexterity

Handwriting dexterity was under investigation and it was found in literature that improved handwriting dexterity is also closely linked to a better handwriting performance because fine motor dexterity is an important performance component in fluent handwriting (Henderson & Pehoski, 2006). Volman et al (2006) conducted a study on handwriting in second and third grade children, with and without handwriting problems and concluded with two underlying factors at work that impacted the quality of handwriting, namely, visual motor integration and fine motor coordination. This is of importance in the context of the study's results, where relatively low fine motor dexterity scores had been observed, with low speed and size scores in the female children's handwriting assessment. Cornhill & Case-Smith (1996) confirmed the link between a lack of adequate fine motor dexterity and handwriting problems.

Although the handwriting scores were positively correlated to improved handwriting dexterity, the dexterity scores were below average for 74% of the children in this study.

5.3.5 Handwriting

The MHA provided a comprehensive evaluation of handwriting for the children participating in this study and provided information regarding the speed, legibility, alignment, size, spacing, form and observations on the handwriting performance, that covered aspects like; pencil grip, adjusting the pencil grip during the assessment, poor sitting balance and weak trunk stability. The strength of this scoring lies in its ability to test, re-evaluate and guide improvement in a child.

According to the Hanover research report (2011), critics on the topic of handwriting instruction in elementary schools, concluded that children should rather spend time learning computer based typing skills and further argued that typing is the skill required by children in modern society. In this regard, manuscript handwriting instruction that takes place in the first three grades in most SA elementary schools and is less controversial than cursive handwriting instruction that starts in the later stages of Grade 3. Certain states in the USA have stopped cursive handwriting instruction, because of the time it takes in a day, time that they argue can be better spent on other educational aspects (Hanover Research Report, 2012). In this controversy, it is important to remember that handwriting is not an automatic developmental process, but rather a skill that needs correct instruction and sufficient practice. If the handwriting of a child is not fluent and automatic in nature, the higher cognitive writing processes can be negatively challenged (Amundson, 2005). The higher cognitive processes influenced by writing includes, weak sentence construction because of a lack of automatic letter formation that can lead to problems in spelling and storytelling (Graham & Harris, 2000).

The mean total handwriting scores of the 34 children in this study scored in the "performance like peers" range with the male children scoring higher than the female children. The speed of the female children's handwriting is noteworthy with a score of "somewhat below peers". The female children displayed superior scores on the form, alignment, spacing and marginally on the legibility sub-categories of handwriting, whereas the male children scored better in the total handwriting performance, speed and size categories. The slow work pace of the females can be a concern and within the classroom environment can have implications. To further emphasise the importance of fluent handwriting at the age appropriate speed, Roaf (1998) in his study concluded that 25% of the learners in the secondary school level still presented with a slow writing speed. This is of great concern, as the expectations exists that at the secondary schooling level the handwriting performance and speed should have been well developed and sufficiently practiced. Henderson & Pehoski (2006) postulated the lack of correct handwriting instruction and late detection of handwriting problems as some of the multiple underlying factors impacting the academic experience. To further illustrate the need for correcting handwriting problems at the elementary schooling level, Paton (2008) voiced his concern regarding half of SA learners that dropped out of school before reaching Grade 12. Roberts (2008) also reported a decline in the pass rate of Grade 12 learners from 62.5% in 2008, that is 2.7% lower than 2007 and a further 4.1% lower than 2006 and there is an opinion by Paton (2008) that this educational crises, in part, can be caused by the lack of the elementary school's facilitation of fluent handwriting. In the light of these comments, the researcher postulates that the emphasis in the culturally rich SA should fall on correct fine motor dexterity and handwriting instruction, after sufficient instruction in foundational aspects of handwriting at the elementary schooling phase. Additionally, early detection and remediation of handwriting problems should be done.

A further cause of concern was incorrect pencil grips observed in almost 50% of the children (n=16), predominantly females displayed incorrect pencil grips. The inadequate isolation and grading of the fingers causes incorrect pencil grips and it directly affects fine motor dexterity. The correct tripod pencil grasp is an important childhood developmental milestone for stimulating the correct cognitive patterns. The additionally observed handwriting faults once again emphasised the importance of an extensive handwriting assessment in children, as whilst the mean total handwriting scores were considered "performance like peers", there were observational aspects that could have been missed, the identification of which may assist children in achieving their optimal functioning in handwriting ability. Even though these handwriting faults were present, no correlation was found between the total handwriting or sub-category handwriting scores and the observed faults. A correlation was observed in the handwriting speed category and faulty trunk stability and this will be further discussed below.

5.4 GENDER DIFFERENTIALS AND CORRELATIONS

When compared to available literature, another handwriting development study, with inclusion of children from the age of 7 years and older, have yielded results that demonstrate a significantly lower quality of writing and slower speed in males compared to females (Ziviani & Watson-Will, 1998) however this is in contradiction to the findings in this study. The quality component in the sub-categories of handwriting yielded results that demonstrated slightly higher averages for legibility, alignment and spacing and significantly higher scores for form in females, with the males outperforming females on the average score for total handwriting and handwriting speed. It is postulated that the more frequent use of handheld videogames by males influenced the handwriting speed, but no significant correlation was found in the analysis of handheld videogames and handwriting speed.

It is interesting that in the form sub-category of handwriting, where the females scored significantly higher than the males, the females' handwriting form was also negatively correlated with their dominant hands' dexterity. Females with better hand dexterity formed their letters with more accuracy. Negative correlations were found for the size of handwriting and the dominant and non-dominant hands' dexterity.

With the male children in this study, there were no significant correlations in handwriting sub-categories and dexterity, potentially due to the small sample size Although no significant difference between genders and dominant and non-dominant hand dexterity was found, the non-dominant hands' average dexterity were very closely scored with 0.3 of a second difference between genders, a difference that is smaller than the sample tested in both Smith & Hong (2000) and Wang et al (2011).

From the above correlations, it can be seen that a superior dexterity score, guaranteed superior handwriting performance in this study's children.

5.5 CORRELATIONS

There was a positive correlation between the total time spent on electronic devices and the non-dominant hand dexterity, implying that with increase device usage, the non-dominant hands displays poorer dexterity. It is important to remember that many of the mobile devices and especially videogames incorporate bilateral hand use, where only certain electronic devices for example mobile devices incorporate predominantly the dominant hand where the index/middle finger or a pen that accompanies the device, is utilised. For mobile devices, it can be argued that the non-dominant hand is only used as a support and not for the operation, especially when handedness has been well developed as in seven to eight year olds. For this reason bilateral dexterity is under question with more frequent device usage.

A weak positive correlation in total device use and total handwriting score, legibility, alignment and speed sub-categories was found and implies that electronic device use does not in essence adversely affect handwriting performance, but can aid handwriting development. The researcher is of the opinion that when the foundational needs of handwriting has been well developed, electronic device use negatively affects handwriting less than if the foundational basis is poorly instructed. The weak positive correlation also implies that electronic device usage can improve handwriting and as will be seen in the next section, one condition is required for this to happen. An interesting correlation exists between the handwriting speed/rate category and faulty trunk stability. Taking into consideration the popularity of tablet computers and weak trunk stability the children displayed and the significant correlation, Straker et al (2008) in their study on posture and muscle activity during tablet computer and desktop computer use, concluded that tablet computer use resulted in different musculoskeletal stress on the body than desktop computer use, with a resultant poorer posture. The reasons for faulty trunk stability can include multiple factors and are beyond the scope of this research, but the popularity of the tablet computer among the children and the above research can explain the weak trunk stability observed in the children. In the light of this increase in handwriting speed with more time spent on electronic devices; it was also found that children's with better trunk stability displayed faster handwriting. This triad of correlational factors implicates posture during electronic device use as was seen in the research conducted by Straker et al (2008) where the posture became poorer with tablet computer use. The researcher is of the opinion that even when the foundational phases of handwriting development has been well developed through proper instruction; the acquisition of poor posture through device use can influence the handwriting speed and performance, as was seen in the results. Moreover, to emphasise the correct posture during device usage, Smith-Zuzovsky & Exner

(2004) found that the quality of the seating position significantly impacted young school children's object manipulation skills.

The faulty pencil grips that were seen amongst almost fifty percent of the sample did not correlate with a poorer handwriting total or sub-categories, and in this regard the other research on handwriting and pencil grips is divided, with no consensus about the influence of pencil grip on handwriting performance.

To gain an improved understanding of the possible correlation between the types of devices used and the handwriting and sub-category scores, no correlation could be found between handheld video game use and the speed of handwriting, but a statistical significance was present for the handheld video game use and the form of the children's handwriting and the manual cellular phone use and the size of the handwriting.

5.6 SUMMARY

In the above discussion the objectives of the study was discussed and related to relevant literature. The main findings of the study revealed that a weak positive correlation exists between the total time spent on electronic device usage in a week and non-dominant dexterity and handwriting, further no correlation existed between total usage and dominant dexterity. Gender differentials revealed that males displayed faster and superior total scores in handwriting. The following section will be the conclusion chapter that will cover aspects such as, achievement of the study aim and the objectives, the limitations of the study, significance of the study and recommendations for future research.

CHAPTER 6

CONCLUSION

6.1 INTRODUCTION

This correlational study investigated electronic device use (type and frequency) in two Grade 2 elementary schools on the East Rand of Gauteng, as well as the handwriting and fine motor dexterity abilities of these children. The researcher endeavours to conclude this study by relating the results to the objectives, and by stating the limitations and significance of the study. Finally, this chapter is concluded with recommendations for future research studies.

6.2 ACHIEVEMENT OF STUDY AIM AND OBJECTIVES

The first objective answered the type and frequency of electronic device use amongst the children with cellular phones (smartphones) being the most frequently used, followed by standard size tablet computers. Devices were most frequently used over weekends with an average of 9.3 hours weekly use. Handheld videogames were significantly used more by males.

The second objective investigated the children's dexterity and revealed slower dexterity scores in 74% of children in their dominant hand and 76% of the children in their non-dominant hands' dexterity, compared to standardised studies regarding dexterity.

The third objective covered the aspect of children's handwriting with the selected test revealing data about the total handwriting ability, covering aspects such as legibility, speed/rate, size, spacing, form, alignment, as well as, observational data such as pencil grip, pencil grip adjustments during writing, sitting balance and trunk stability. Children scored similarly to their peers in the total, legibility, form, alignment and spacing categories of handwriting with the size and speed categories falling somewhat below their peers.

Objective four highlighted the gender differences in dexterity and handwriting. With dexterity, the females on average outperformed the males in the dominant hand by more than one second and in the non-dominant hand by more than two seconds. In handwriting, the females outperformed the males in form, alignment and spacing but the males outperformed the females in total handwriting, speed and size categories. The form of the females and the speed of the males were the only statistical significant values. Handwriting legibility displayed almost identical averages between genders. Almost fifty percent of the children (10 female and 6 male), displayed incorrect pencil grips and not the tripod grip that is age appropriate at 7 to 8 years old. Seven females and no males had a trunk stability challenge and the trunk stability was the only observational fault that was significantly correlated to a poorer handwriting speed or any other aspect of the handwriting assessment. One female displayed poor sitting balance and four females and one male frequently adjusted the pencil grip. In the gender correlations between handwriting and dominant hands' dexterity, the females displayed a weak negative correlation and for the non-dominant hands' dexterity both genders displayed a weak negative correlation. For the sub-categories form and size of handwriting a negative correlation was found for dominant hands' dexterity and for the non-dominant hands' dexterity the size of handwriting also displayed a negative correlation.

The fifth objective highlighted correlations in electronic device use, dexterity and handwriting and revealed the following results. A weak positive correlation existed between the total weekly electronic device use and the total handwriting, legibility, alignment and speed sub-categories. A weak negative correlation was measured between the total electronic device use and the form of handwriting. A weak positive correlation for the total weekly electronic device use and the non-dominant hands' fine dexterity scores was present.

6.3 LIMITATIONS OF THE STUDY

A high attrition rate presented itself in the selection of the schools and children. Three out of five schools did not grant permission to conduct this study at these institutions. Further, many sampled children had to be excluded due to previous remediation, repetitions of grades or parents not granting consent for inclusion. Due to time restraints these schools could not be replaced by other sampled schools. Therefore, the sample size was relatively small and the male children small in numbers, compared to the female children. Gender correlations between the dexterity and sub-categories of handwriting in the male children were deemed important, but due to the small sample size of males, no statistical significance could be measured. To this end, most continuous measures were not normally distributed, more robust parametric tests could not be utilised and therefore, non-parametric tests were utilised in the statistical analysis.

6.4 SIGNIFICANCE OF THE STUDY

The significance in this study lies in gathering data in the SA context regarding electronic device type and frequency of use in Grade 2 elementary school children and correlating this to handwriting dexterity. As far as the researcher is aware, this study provides initial data on the usage of these devices compared to handwriting and fine motor dexterity, as a first step in understanding these variables. In doing so, this can be the start to answer the informal plea of teachers and the formal plea of researchers, to gain an understanding of how these modern devices impacts children and scholastic performance that is underpinned by handwriting and dexterity. The cognitive mapping of the hand has been extensively discussed in physiological literature, as was mentioned in this study. The resulting effects of the frequent motor action of the hands during the play of electronic devices are largely unknown. This also applies to the cognitive mapping during the use of electronic devices. As this question surpasses the aim and objectives of this study, this correlation results can lead to further research investigating these questions. In so doing, preventative or perhaps even promotive advice can be given to children, parents, teachers and the society as a whole.

As this is the first study investigating the electronic device use of Grade 2 children and correlating the usage to their fine motor dexterity and handwriting ability, further experimental research is required before preventative advice can be given to teachers, parents, children and school boards, on whether electronic devices use should be increased or kept to a minimum. Until further experimental research investigating similar variables have been undertaken, these results cannot be generalised to other schools nationally or internationally. However, the statistical significant correlation between handwriting speed and truck stability should give valuable information to teachers and Occupational Therapist, regarding the continued importance of promoting the correct sitting posture before handwriting tasks. Further, the development phases stimulating gross motor task and correct truck stability should be emphasised as early as possible in the foundation schooling phase and if not developed appropriately in the early phases, should be re-evaluated and corrected when children are diagnosed with handwriting problems.

6.5 RECOMMENDATIONS FOR FUTURE RESEARCH

A larger sample size with equal gender distribution can be utilised in future studies, investigating the electronic type and frequency of use of 7-8 year olds and correlate this to the handwriting and fine motor dexterity measurements. In doing so, more robust parametric statistical testing can be done in order to answer the hypotheses under investigation.

A longitudinal empirical study investigating the male and female children from Grade 0 to Grade 3 is recommended, where the electronic device usage diarised and the questionnaire measuring the use, standardised. It is believed that these implemented measures can measure the usage with more accuracy, than when the parents have to rely on their memory.

Other standardised tests for dexterity and handwriting, that measures the gross motor skills and posture of the children can also give valuable data in order to gain an improved understanding of the variables under investigation.

REFERENCES

Fleishman E, Ellison G. (1962) A factor analysis of fine motor manipulative tests. *Journal of Applied Psychology,* 46: 96-105.

Mennen U, van Velze C. (2008) The Hand Book. 3d ed. Hatfield, Pretoria: Van Schaik Publishers.

Merck: Manual of Medical Information. (2003) 2nd ed. New York, United States of America: Pocket Books.

Amundson SJ. (2005) Prewriting and handwriting skills. In: Case-Smith J, editor. Occupational therapy for chidren. 5th ed. Missouri: Elsevier Mosby, pp. 587-614.

Henderson A, Pehoski C. (2006) Hand function in the child. Foundations for remediation. 2nd ed. Mosby, Missouri: Elsevier.

Van der Merwe J, Smit N, Vlok B. (2011 March) A survey to investigate how South African occupational therapists in private practice are assessing and treating poor handwriting in foundation phase learners (Dissertation).

Feder KP, Majnemer A. (2007) Handwriting development , competency, and intervention. *Dev Med Child Neurol,* 49: 312-318.

Wartella EA, Vandewater EA, Rideout VJ. (2005) Introduction: Electronic media in the lives of infants, toddlers and pre-schoolers. *American Behavioural Scientist,* 48(5): 501-504.

Tofler A. (1980) The third wave. London: Pan Books Ltd in association with William Collins Sons & Co. Ltd.

Bryant A, Akerman A, Drell J. (2010) Diminutive subjects, design strategy, and driving scales: Preschoolers and the Nintendo DS. *The International Journal of Computer game research,* 10(1).

Van Hartingsveldt MJ, De Groot IJM, Aarts PBM, et al. (2011) Standardized tests of handwriting readiness: a systematic review of the literature. *Developmental Medicine and Child Neurology,* 53: 506-515.

Tseng MH, Chow SM. (2000) Perceptual-motor function of school-age children with slow handwriting speed. *Am J Occup Ther,* 54: 83-8.

Straker LM, Coleman J, Skoss R, et al. (2008) A comparison of posture and muscle activity during tablet computer, desktop computer and paper use by young children. *Ergonomics,* 51(4): 540-555.

Hanover Research Report. (2012) The importance of teaching handwriting in the 21st century. Available from: http://www.hanoverresearch.com/

Common sense media. (2013) Zero to Eight: Children's Media Use in America Available from: http://www.commonsensemedia.org/

Tseng MH, Murray E. (1994) Differences in perceptual motor measures in children with good and poor handwriting. *Occup Ther J* Res, 14: 19-36.

Kwa-Zulu Natal Department of Education. (2006) "Literacy Learning Programmes for the Foundation Phase". Kwa-Zulu Natal Department of Education. Available from: http://education.gov.za/mainDocument.scp?src=docu&xsrc=pol

McHale K, Cermak SA. (1992) Fine motor activities in elementary school: Preliminary findings and provisional implications for children with fine motor problems. *Am J Occup Ther,* 46(10): 898-903.

Connelly V, Gee D, Walsh E. (2007) A comparison of keyboarded and handwritten compositions and the relationship with transcription speed. *Br J Educ Psychol*, 77(2): 479-92.

Naidoo P, Engelbrecht A, Lewis S, Kekana B. (2009) Visual-motor integration (VMI) - a predictor for handwriting in Grade 0 children. *South African Journal of Occupational therapy,* 39(2): 18-21.

Volman MJM, van Schendal BM, Jongmans MJ. (2006) Handwriting difficulties in primary school children: A search for underlying mechanisms. *Am J Occup Ther,* 60(4): 451-60.

Christensen CA. (2005) The role of orthographic-motor integration in the production of creative and well-structured written text for students in secondary school. Educ Psychol, 25(5): 441-53.

Zwicker JG. (2005) Effectiveness of occupational therapy in remediating handwriting difficulties in primary students: Cognitive versus multisensory interventions [thesis]. Canada: University of Victoria, [cited June 2014]. Available from: http://hdl.handle.net/1828/49.

Graham S, Struck M, Santoro J, Berninger VW. (2006) Dimensions of good and poor handwriting legibility in first and second graders: motor programs, visual-spatial arrangement, and letter formation parameter setting. *Developmental Neuropsychology,* 29(1): 43-60.

Braswell GS, Rosengren KS, Peirroutsakos SL. (2007) Task constraints on preschool children's grip configurations during drawing. *Developmental Psychobiology,* 49(2): 216-225.

Karlsdottir R, Steffansson T. (2002) Problems in developing functional handwriting. *Percept Mot Skills,* 94: 623-662.

Ziviani J and Watson-Will A. (1998) Writing speed and legibility of 7-14-year-old school students using modern cursive script. *Aust Occup Ther J,* 45: 59-64.

Maier M, Armand J, Kirkwood P, et al. (2002) Differences in the corticospinal projections from primary motor cortex and supplementary motor area to macaque upper limb motoneurons: an anatomical and electrophysiological study. *Cerebral cortex*, 12: 281-296.

Fogassi L, Gallese V, Buccino G, Craighero G, Fadiga L, Rizzolatti G. (2001) Cortical mechanisms for the visual grasping of hand grasping movements in the monkey: A reversible inactivation study. *Brain*, 124: 571-583.

Classen J, Liepert J, Wise SP, Hallett M, Cohen LG. (1998) Rapid plasticity of human cortical movement representation induced by practice. *Jounal of Neurophysiology,* 79: 1117-1123.

Butefisch CM. (2004) Plasticity in the human cerebral cortex: Lessons from the normal brain and from stroke. *Neuroscientist*, 10: 163-173.

Smith YA, Hong E. (2000) Normative and validation studies of the nine-hole-peg test with children. *Perceptual and Motor Skills*, 90: 823-843.

Wang Y, Magasi SR, Bohannon RW, et al. (2011) Assessing Dexterity Function: A Comparison of Two Alternatives for the NIH Toolbox. *J Hand Ther*, 24(4): 313-321.

Amundson SJ. (1995) *Evaluation Tool of Children's Handwriting*. Homer, AK, OT Kids.

Gardner M. (1998) *The test of handwriting skills: manual*. Hydesville, CA, Psychological and Educational Publications.

Phelps J, Stempel L. (1984) *Children's handwriting evaluation scale*. Dallas. TX, Scottish Rite Hospital for Crippled Children.

Steinhardt RC, Richmond JE, Smith W. (2005) Writing Rate Information Test. Durban (SA): Occupational Therapy Department, Livingstone Primary School.

Reisman JE. (1999) Minnesota Handwriting Assessment. San Antonio, TX: Psychological Corporation.

Collins W, Candler C, Sanders J. (2008 January) Evidence Topic: Handwriting Assessment. Available from:
https://www.region10.org/r10website/assets/File/handwriting_assess.pdf

Revelle GL, Medoff L. (2002) Interface design and research process for studying the usability of interactive home-entertainment systems by young children. *Early education & development,* 13(4): 423-434.

Bryant A, Akerman A, Drell J. (2010) Diminutive Subjects, and Driving Sales: Preschoolers and Nintendo DS. *International Journal of Computer game research*, 10(1).

USA Market Research. (2013) Internal report. Available from: http://www.ibisworld.com/

Rideout V and Hamel E. (2006) The media family: Electronic media in the lives of infants, toddlers, pre-schoolers and their parents. Menlo Park, CA: Henry J. Kaiser Family Foundation.

Nickelodeon. (2009) iPhone and iTouch Research. Internal report. Available from: http://gamestudies.org/1001/articles/bryant_akerman_drell

Filipowich M. What are the Advantages and Disadvantages of Correlational Research? Available from: http://www.ehow.com/info_8359597_advantages-disadvantages-correlation-research.html

Zarghom S, Di Fonzo D and Leung F. (2013) Does socioeconomic status affect patients' ease of use of a touch-screen (iPad) patient survey? *Interact J Med Res*, 2(1).

Feder KP, Majnemer A, Bourbonnais D, et al. (2005) Handwriting performance in preterm children compared with term peers at 6 to 7 years. *Dev Med Child Neurol,* 47: 163-170.

Steger J, Imhof K, Coutts E, et al. (2001) Attentional and neuromotor deficits in attention-deficit-hyperactivity disorder. *Dev Med Child Neurol,* 43:172-179.

Fuentes CT, Mostofsky SH, Bastian AJ. (2009) Children with autism show specific handwriting impairments. *Neurology,* 73:1532-1537.

IBM Corporation. (2012) IBM SPSS Statistics 21. IBM Corportation, Armonk, NY: IBM.

Mack N, Woodsong C, MacQueen K, Guest G and Namsey E. (2005) Qualitative Research Methods: A data Collector's field guide. Family Health International: North Carolina.

Pew Research Center, February, 2014 "Emerging Nations Embrace Internet, Mobile Technology."

Von Salisch M, Oppl C, Kristen A. (2006) What attracts children? In P. Vorderer & J. Bryant (Eds.), Playing video games: Motives, responses and consequences.(147-163). Mahwah, NJ: Lawrence Earlbaum Associates.

Cornhill H, Case-Smith J. (1996) Factors that relate to good and poor handwriting. *Am J Occup Ther,* 50: 732-739.

Graham S, Harris KR. (2000) The role of self-regulation and transcription skills in writing and writing development. *Educ Psychologist*, 35(1): 3-12.

Roaf C. (1998) Slow hand: A secondary school survey of handwriting speed and legibility. Support Learn [Internet]. Available from: Academic Search Premier database.

Paton C. (2008) A letdown. FinancialMail [Internet]. March 28. Available from http://free.financialmail.co.za/report08/skillsdev08/askills.htm.

Roberts J. (2008 December) Matric pass rate down from 2007. Cape Times [Internet]. Available from: http://www.iol.co.za/index.php?from=rrs_South%20Africa&set_id=1&click_id=13&art_id=13&art_id+vn20081231061756594C391799

Smith-Zuzovsky N, Exner CE. (2004) The effect of seated positioning quality on typical 6- and 7-year-old children's object manipulation skills. *Am J Occup Ther*, 58: 380-388.

Appendix 1

Standardised scoring for each category for the testing

2nd Grade	Rate Score	Legibility Score	Form Score	Alignment Score	Size Score	Spacing Score
PERFORMING LIKE PEERS	29-34	34	31-34	31-34	27-34	32-34
PERFORMING SOMEWHAT BELOW PEERS	17-28	32-33	28-30	26-30	19-26	29-31
PERFORMING WELL BELOW PEERS	16 or less	31 or less	27 or less	25 or less	18 or less	28 or less

Source: (Reisman, 1999)

Appendix 2

Competitive results of the NHPT (secs) for dominant and non-dominant hand

AGE IN YEARS	COMPLETION TIME			
	Boys		Girls	
	Mean	Standard Deviation	Mean	Standard Deviation
Dominant Hand				
7 years	21.70	2.30	20.95	2.46
8 years	20.70	2.02	19.80	2.75
9 years	18.85	2.27	18.21	2.05
Average mean for 7-9 years	20.41		19.65	
Non-dominant Hand				
7 years	24.93	3.41	23.78	2.50
8 years	22.27	2.59	22.35	2.43
9 years	20.68	2.21	20.57	2.47
Average mean 7-9 years	22.63		22.23	

Source: (Wang et al, 2011)

Appendix 3

Gauteng Educational Department Ethical Clearance

GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

For administrative use:
Reference no. D2015 / 025 G

GDE GROUP RESEARCH APPROVAL LETTER

Date:	8 May 2014
Validity of Research Approval:	8 May to 3 October 2014
Name of Supervisor/s:	Naidoo P.
Name/s of Researchers	Keller M.M.; Joubert A and Joubert R.
Address of Supervisor:	21 Mendelsohn Street
	Witfield
	Boksburg
	1459
Telephone Number:	011 826 4255; 011 972 4897; 011 394 8857 084 402 9493; 082 374 1390; 073 462 5622
Fax Number:	011 975 6942
Email addresses:	moniquekeller@telkomsa.net; aneskajoubert@gmail.com
Research Topic:	The association between electronic device use on fine motor dexterity and handwriting legibility and speed in Grade 2 elementary school children
Number and type of schools:	FIVE Primary Schools
District/s/HO	Gauteng East

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be

2014/05/09

1

Making education a societal priority

Office of the Director: Knowledge Management and Research
9th Floor, 111 Commissioner Street, Johannesburg, 2001
P.O. Box 7710, Johannesburg, 2000 Tel: (011) 355 0506
Email: David.Makhado@gauteng.gov.za
Website: www.education.gpg.gov.za

presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

1. *The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.*
2. *The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.*
3. *A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.*
4. *A letter / document that outlines the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.*
5. *The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.*
6. *Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.*
7. *Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.*
8. *Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.*
9. *It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.*
10. *The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.*
11. *The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.*
12. *On completion of the study the researcher/s must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.*
13. *The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.*
14. *Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.*

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards

Dr David Makhado
Director: Education Research and Knowledge Management

DATE: 2014/05/09

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Appendix 4

Ethical Clearance : UKZN Biomedical Ethics Research Committee

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UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

29 October 2014

Dr Monique Keller
Arwyp Medical Suite 2nd Floor
22 Pine Avenue
Kempton Park
1619
moniquekeller@telkomsa.net

Dear Dr Keller

PROTOCOL: The association between electronic device use on fine motor dexterity and handwriting legibility and speed in grade 2 elementary school children: Degree Purposes (Masters). BREC REF: BE292/14.

EXPEDITED APPLICATION

A sub-committee of the Biomedical Research Ethics Committee has considered and noted your application received on 09 June 2014.

The study was provisionally approved pending appropriate responses to queries raised. Your responses received on 21 October 2014 to queries raised on 14 October 2014 have been noted by a sub-committee of the Biomedical Research Ethics Committee. The conditions have now been met and the study is given full ethics approval.

This approval is valid for one year from **29 October 2014**. To ensure uninterrupted approval of this study beyond the approval expiry date, an application for recertification must be submitted to BREC on the appropriate BREC form 2-3 months before the expiry date.

Any amendments to this study, unless urgently required to ensure safety of participants, must be approved by BREC prior to implementation.

Your acceptance of this approval denotes your compliance with South African National Research Ethics Guidelines (2004), South African National Good Clinical Practice Guidelines (2006) (if applicable) and with UKZN BREC ethics requirements as contained in the UKZN BREC Terms of Reference and Standard Operating Procedures, all available at http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx.

BREC is registered with the South African National Health Research Ethics Council (REC-290408-009). BREC has US Office for Human Research Protections (OHRP) Federal-wide Assurance (FWA 678).

The sub-committee's decision will be **RATIFIED** by a full Committee at its meeting taking place on **09 December 2014.**

We wish you well with this study. We would appreciate receiving copies of all publications arising out of this study.

Yours sincerely

Professor D.R Wassenaar
Chair: Biomedical Research Ethics Committee

Biomedical Research Ethics Committee
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