

University of Pretoria etd – Grobler, R (2004)

**THE INFLUENCE OF THERAPEUTIC HORSE RIDING
ON NEUROPSYCHOLOGICAL OUTCOMES IN CHILDREN
WITH TOURETTE SYNDROME**

by

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submitted in partial fulfillment of the requirements for the degree of

MA (Psychology)

**in the faculty of Humanities
University of Pretoria, PRETORIA**

January 2004

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SUMMARY

The aim of this study was to determine executive function outcomes after an equi-therapy intervention in a group of Tourette syndrome children. Equi-therapy is a new form of therapeutic horse riding, which is related to the stimulation of the vestibular system through sensory integration in the brain.

For this study a non-equivalent control group design was implemented. The study consisted of 8 Tourette syndrome children aged between 9 and 15, who were referred after a definite Tourette syndrome diagnosis from various neurologists and paediatricians.

Both groups were evaluated on a battery of 6 neuropsychological tests measuring various aspects of executive function before and after receiving the therapeutic horse riding intervention. The tests used were the Wisconsin Card Sorting Test, the Stroop Colour Word Test, the Rey-Osterrieth Complex Figure Test, the Trail Making Test A and B, the Raven's Standard Progressive Matrices and the Symbol Digit Modalities Test. Qualitative inputs were also included in the study. These consisted of behavioural checklists completed by the participants' parents, the evaluation of the participants' copy drawings as 'frontal' or 'normal' obtained from the Rey-Osterrieth Complex Figure test, and results of tests that were administered by an occupational therapist as part of the required evaluation for the therapeutic horse riding (equi-therapy) itself.

Results of the neuropsychological tests indicated significant differences for the Wisconsin Card Sorting Test, Stroop Colour Word Test and the Symbol Digit Modalities Test, indicating improvements in selective attention, cognitive flexibility, visuospatial constructional ability, visuomotor integration, visual memory and organisational strategies. The qualitative results indicated improvements in emotional and behavioural aspects.

Executive abilities are a very complex system and evaluation should always include robust and sensitive neuropsychological tests. It seems as if Tourette syndrome could be directly related to executive dysfunction, but not in a simple manner as aspects may vary due to other more complex factors that may contribute to these dysfunctions. However, for equi-therapy as an alternative form of therapy, the opportunity should not be lost to establish its efficacy because of the possible beneficial outcome.

KEY TERMS

Executive function

Tourette syndrome

Neuropsychological assessment

Therapeutic horse riding

Equi-therapy

Sensory integration

OPSOMMING

Die doel van hierdie studie was om die moontlike uitwerking van equi-terapie op die uitvoerende funksies van kinders met Tourette sindroom, na te vors. Equi-terapie is 'n nuwe vorm van terapeutiese perdry wat verband hou met die stimulasie van die vestibulêre stelsel deur sensoriese integrering in die brein.

Vir hierdie studie is 'n nie-ekwivalente kontrolegroep-ontwerp geïmplementeer. Die studie het die toetsing behels van 8 Tourette sindroom kinders met ouderdomme wat gewissel het van 9 – 15 jaar. Hierdie kinders is verwys nadat 'n definitiewe Tourette sindroom diagnose deur verskeie neuroloë en pediater, gedoen is.

Beide groepe is geëvalueer deur 'n reeks van 6 neuro-psigologiese toetse wat verskeie aspekte van uitvoerende funksies gemeet het voor en na blootstelling aan die terapeutiese perdry intervensie. Die toetse wat gebruik is, is die 'Wisconsin Card Sorting Test', die 'Stroop Colour Word Test', die 'Rey Osterrieth Complex Figure Test', die 'Trail Making Test A and B', die 'Raven's Standard Progressive Matrices' en die 'Symbol Digit Modalities Test'. Kwalitatiewe insette is ook ingesluit in die studie. Dit het gedragsverwante vrealyste behels wat deur die ouers van die betrokke deelnemers voltooi is, die evaluering van nagebootse sketse as 'frontaal' of 'normaal' volgens die 'Rey Osterrieth Complex Figure Test' en resultate van toetse wat uitgevoer is deur 'n arbeidsterapeut as deel van die vereiste evaluering vir die terapeutiese perdry (equi – terapie).

Resultate van die neuro-psigologiese toetse het beduidende verskille getoon by die 'Wisconsin Card Sorting Test', die 'Stroop Colour Word Test' en die 'Symbol Digit Modalities Test' wat verbeterde prestasie aangedui het op selektiewe aandag, kognitiewe buigsaamheid, visuele-geheue, visueel-motoriese integrering en strategiese organisasievermoëns. Die kwalitatiewe resultate het 'n verbetering in emosionele en gedrags areas getoon.

Uitvoerende funksies is 'n baie komplekse stelsel en evaluasie daarvan moet altyd sensitiewe neuro-psigologiese toetse in die verband insluit. Dit wil voorkom of Tourette sindroom verband hou met disfunksionele uitvoerende funksies, nie op 'n eenvoudige wyse nie, maar as gevolg van meer komplekse faktore wat bydra tot disfunksionaliteit. Alhoewel, vir equi-terapie, as 'n alternatiewe vorm van terapie moet verdere navorsing nie nagelaat word nie, aangesien dit kan bydra tot die uitbreiding van moontlike voordelige resultate.

SLEUTELTERME

Uitvoerende funksie

Tourette sindroom

Neuro-psigologiese evaluasie

Terapeutiese perdry

Equi-terapie

Sensoriese integrasie

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CHAPTER 1 INTRODUCTION

1.1 Introduction

Executive function is often considered to be the basis of cognitive and psychological functioning. Functions such as attention and concentration, drive and motivation, cognitive/ mental flexibility, planning and organisational skills, the ability to recognise and correct mistakes, the ability to respond to feedback cues, and the ability to understand the consequences of behaviour are mainly related to the prefrontal regions of the brain, but are not normally localised to these areas (Rothenberger, 1990; Spreen & Strauss, 1998).

Tourette syndrome is a medical condition defined as clinically heterogeneous, which has hampered researchers in identifying causal biochemical variables and makes it more difficult to interpret epidemiological, genetic and therapeutic studies. It has many similarities with aspects of frontal lobe dysfunction (Denckla, 1996; Comings, 1990; Gedye, 1991; Rothenberger, 1990).

In a new form of therapeutic horse riding known as equi-therapy, focus is mainly on the stimulation of the vestibular system through sensory integration in the brain, which can improve various functions such as motor planning, and the execution of tasks that require reasoning and various intellectual abilities (Ayres, 1979). As previously mentioned, Tourette syndrome patients are often found to demonstrate dysfunction of various executive functions. Therefore, once they have been stimulated by equi-therapy, an improvement of these functions can possibly be expected.

1.2 Aims of the study

The main area of scientific investigation of this study was to determine the effect on the executive functioning of Tourette syndrome children who

received an intervention called equi-therapy, a new form of therapeutic horse riding. A battery of 6 neuropsychological tests that have been found to be sensitive to executive function were administered to evaluate this possible effect.

A possible improvement in the Tourette children's executive functions could be of great importance to Tourette syndrome research and to equi-therapy as a new form of therapeutic riding. Various studies have indicated that Tourette syndrome children often have deficits in certain executive functions (Denckla, 1996; Fischer, Barkley, Edelbrock & Smallish, 1990; Gorenstein, Mammato & Sandy, 1989). An intervention such as equi-therapy applies the neuropsychological focus of Ayres (1979), namely, sensory integration stimulation of the vestibular system and the somato-sensory system, perception functions of the limbic system, and hemispheric integration of the higher cognitive functions. Therefore, these research findings could be utilised in more detailed research studies in the future.

Furthermore, therapeutic horse riding or, more specifically, equi-therapy as a new form of therapeutic riding has not yet been researched in the South African context. Although numerous studies have been conducted world-wide using therapeutic riding as an intervention in various disorders, no specific studies with Tourette syndrome or equi-therapy were found (MacKinnon, 1995; Rufus, 1997).

Thus the following hypothesis was investigated in this study:

The therapeutic horse riding will have a positive influence on the executive functions of the Tourette syndrome participants.

1.3 Overview of the study

When formulating executive function, 'self-structure' can be seen as the most important component of accomplishment for an individual (Goldstein & Green,

1995). These functions include various loosely related higher-order cognitive processes such as: initiation, planning, hypothesis generation, cognitive flexibility, decision making, regulation, feedback utilisation, judgement and self-perception/self-monitoring necessary for conceptual appropriate behaviour – overall organisation and control of conscious activities (Spreeen & Strauss, 1998). Executive functioning is normally related to the prefrontal regions of the brain, but deficits/impairments are not always localised to these regions. Executive function is highly sensitive to damage in other parts of the brain and should always be considered in that light (Denckla, 1996; Du Toit, 1986; Lezak, 1995; Spreeen & Strauss, 1998). (A more detailed discussion on executive function follows in chapter 3.)

According to Luria (1980) the brain is divided into three basic functional units. Unit one (the upper and lower brainstem and reticular formation) regulates the arousal/energy level of the cortex as well as the maintenance of proper muscle tone. Unit two (parietal, temporal and occipital regions) plays a key role in the reception, integration and analysis of sensory information from both the internal and external environment. Unit three (the frontal and prefrontal lobes) is the executive section of the brain and is involved in planning, executing, and verifying behaviour – overall organisation and control of conscious activity. All behaviour is regarded as the product of groups of brain areas working together as a functional system, each part of the system making a specific contribution to the functioning of the system as a whole. The type of symptoms a person may display will depend on which part of the functional system has been compromised. With regard to this study, unit three of Luria's theory is of main interest, although units one and two are also directly related. Aspects of arousal are suggested in Tourette syndrome and the stimulation of sensory integration is directly related to equi-therapy. (A detailed discussion of how the evaluated executive functions interrelate within a systems conception of brain functioning follows in chapter 3).

Tourette syndrome is a neurological disorder characterised by tics. It is believed that an abnormal metabolism of neurotransmitters dopamine and

serotonin cause this genetically transmitted disorder. Boys are likely to display Tourette syndrome symptoms 3 to 6 times more frequently than girls. If we look at the definition of Tourette syndrome according to the DSM-IV, it stipulates that the person must have had motor (blinking, squinting, or rolling the eyes, smacking or licking the lips, or sticking out the tongue) and vocal (throat clearing, grunting, coughing, burping, hiccuping, barking, sniffing, and snorting) tics for more than a year, and not been without tics for more than two months at a time. Onset for this disorder is before the age of 18, although the Tourette Syndrome Association Medical Advisory Board is currently working to change the onset age back to 21 years as it was previously listed in the DSM-III-R (Bruun & Bruun, 1994; Moe, 2000). (A more detailed discussion on Tourette syndrome follows in chapter 2.)

Furthermore Tourette syndrome is often associated with problems/conditions other than difficulties stemming from tics. These include attention disorders such as attention deficit hyperactive disorder and attention deficit disorder, obsessions and compulsions diagnosed as obsessive-compulsive disorder, learning disorders, various social and emotional behavioural problems as well as sleep disorders (Bruun & Bruun, 1994).

Considering these related conditions when focusing on the executive functioning of Tourette syndrome children, the following features were investigated scientifically through neuropsychological tests in relation to the influence of the therapeutic horse riding intervention: planning and organisational abilities, attention, memory, problem solving, intellectual efficiency and conceptual abilities, cognitive flexibility, certain behavioural and social function. These executive features are all interrelated with certain patterns/behaviours in Tourette syndrome children as well as the other conditions mentioned above. Various researchers such as Denckla, (1996), Fischer *et al.*, (1990), Gorestein *et al.*, (1989) and Pineda, Alfredo & Roselli, (1999) just to mention a few, have already made this connection. The majority of these studies were mainly neuropsychologically tested according to their relation to executive function, but no studies could be found that

included subjection to an additional intervention, such as therapeutic horse riding, to measure its influence on executive functioning.

With regard to the therapeutic horse riding as an intervention, only 2 studies with a diagnosis related to Tourette syndrome were found, although executive function evaluations were not part of either of the investigations. Basile (1997) did a study on the effect of therapeutic horse riding on the behaviour and self-esteem of attention deficit hyperactive disorder children. Another study was conducted by Rufus (1997), measuring the effect of therapeutic riding on the self-concept of learning disabled children. (The latter is also the only registered study in South Africa to date relating to therapeutic horse riding.)

Many studies have proven that therapeutic horse riding, which includes various categories such as hippotherapy, remedial driving and vaulting, and riding for the disabled, can make a difference in balance, posture, co-ordination, various behavioural and emotional patterns as well as improving various learning disabilities (MacKinnon, 1995; Von Arbin, 1994). However, the focus has seldom been on why and how these areas actually improve. Equi-therapy uses this focus, with specific relation to the stimulation of the vestibular system through sensory integration in the brain. (A more detailed discussion on this theory follows in chapter 3.)

1.4 Conclusion

If the stated hypothesis is supported, it could imply the beginning of a broader area of research involving various combined fields of study such as the medical and health profession and even alternative or holistic related therapies such as reflexology and other animal therapies. Results obtained can contribute to existing theories and research related to the cognitive functioning of Tourette syndrome patients as well as a possible treatment of these functions.

In the following chapter a theoretical overview and various related studies of Tourette syndrome are discussed, followed by a theoretical overview of executive function and equi-therapy as a new form of therapeutic horse riding in chapter 3. The research method used in this study is discussed in chapter 4, followed by the results obtained in chapter 5. A general discussion on the results as well as limitations and recommendations for further research follow in chapter 6.

CHAPTER 2

THEORETICAL OVERVIEW OF TOURETTE SYNDROME

2.1 Tourette syndrome

The first clear medical description of Tourette syndrome dates back to 1825, when Jean Marc Gaspard Itard, chief physician at Institution Royale des Sourds-muets in Paris, reported the case of the French noblewoman, Marquise de Dampierre. The now famous marquise, developed motor tics at the age of seven, and later, at the time of her marriage, began to use swear words, which made her socially unacceptable in her circle, and therefore was compelled to live as a recluse until she died at the age of 85. Itard did not regard this as a new disorder, but rather as one of the most extraordinary forms that clonic convulsions could assume (Kushner, 1999; Robertson, 1989).

This chapter provides a general overview of this relatively unknown and often misdiagnosed syndrome.

2.1.1 History

In 1885, 60 years after Itard published this description, a young Parisian neurologist, Georges Gilles de la Tourette at the Salpêtrière Hospital in Paris, selected this case as his first example of the illness. In his classic publication of the same year, he described a combination of involuntary motor movements and spontaneous shouting and cursing as a single disease that he called 'maladie des tics' (Gilles de la Tourette, 1885). This was also the first time that he introduced the term, coprolalia, to describe the use of obscenities. Later Gilles de la Tourette's mentor Jean-Martin Charcot, chief physician of the Salpêtrière Hospital and one of the foremost neurologists of late 19th-century France, renamed the convulsive tic illness 'maladie des tics de Gilles de la Tourette' in

honour of Gilles de la Tourette. However, since the late 1960s, 'Tourette syndrome' and 'Gilles de la Tourette syndrome' have been used interchangeably to indicate the same disorder (Kushner, 1999) -- first by Arthur K. Shapiro and his colleagues, and later in the 1980s in the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders* (the DSM-III and IV).

Since then, other cases have been documented by various authors. Shapiro, Shapiro, Bruun and Sweet (1988) traced the history of Tourette syndrome, noting that between 1885 and 1965 only about 50 cases were described in the literature. They divided the history into several periods, with dominant themes including an emphasis of pathogenesis, such as 'neuropathic heredity', to predominantly treatment areas, spanning psychoanalysis, behavioural techniques and chemotherapy. Furthermore, the history of Tourette syndrome is thoroughly covered by Kushner (1999) in his book *A Cursing Brain? The Histories of Tourette Syndrome*. He describes the early years of Tourette syndrome in France as the psychological/psychoanalytical phase of causation, the infectious era, and finally, modern times with the acknowledged clinical similarities and biological nature of the disorder.

However, today Tourette syndrome is well established as a medical condition and each year hundreds of publications about the various aspects of Tourette syndrome appear in medical and scientific literature.

2.1.2 Definition of Tourette syndrome

Tourette syndrome is now recognised to be a chronic neuropsychological disorder with a suggested genetic basis. Abnormalities in specific parts of the brain have also been demonstrated. In earlier years it was thought that Tourette syndrome was a psychological disorder, but recently there have been many studies suggesting a biological aetiology (Leckman & Cohen, 1998).

If we look at the diagnostic criteria for Tourette syndrome according to the two major currently accepted diagnostic systems: the International Classification of Diseases (10th edition) of the World Health Organisation (WHO), published in 1992, and the *Diagnostic and Statistical Manual of Mental Disorders* (DSM), (4th edition) of the American Psychiatric Association (APA), published in 1994, two major differences can be found between them. They are, firstly, that the DSM has always stipulated the age by which time the symptoms must have started (but each DSM has had a different upper age limit), and secondly, the current DSM suggests that distress and significant impairment must occur, a point of disagreement for many authorities. What these two systems do have in common, however, is that they both broadly stipulate the following diagnostic criteria for Tourette syndrome: Both multiple motor tics (twitches) and one or more vocal (phonic) tics (noises), which occur many times a day in bouts, the number, frequency and complexity of which change over time (wax and wane). One tic may even be replaced by another, however the tics must have been present for over 12 months and for more than two months at a time, age at onset under 21 years.

The age at onset of Tourette syndrome symptoms ranges from two to 21 years, with a mean of five to seven years being commonly reported, usually beginning with facial tics such as excessive eye blinking, eye rolling, nose twitching, and smacking or licking of the lips (Comings, 1990). The onset of vocal tics is usually later, with a mean age at onset of 11 years. The most common vocal tics are excessive sniffing, throat clearing, coughing, or grunting. Coprolalia (inappropriate and involuntary uttering of obscenities or socially objectionable words or phrases) as a first symptom is rare, although experts used to consider it a hallmark of Tourette syndrome in earlier years. In most cases, the first symptom is a single, simple tic such as an eye blink, although complex or

multiple tics may occur from the start of the disorder (Bruun & Bruun, 1994; Carroll & Robertson, 2000; Comings, 1990).

A recent study by Leckman and Cohen (1998) has shown a more favourable prognosis of Tourette syndrome than was previously recognised. After the onset of the tics (the average age of onset being 5 years), a period follows during which there is a progressive pattern of tic worsening, and the average age of the most severe tics was 10 years. By the age of 18 years, however, nearly half the Tourette syndrome adolescents examined in the study were virtually tic free. This gives reassurance that the prognosis of Tourette syndrome is not always bleak.

However, despite the formulation of these criteria, Tourette syndrome is a disorder that is clinically heterogeneous, a problem that has greatly hampered research efforts to identify causal biochemical variables, and has led to difficulties in interpreting epidemiology, and genetic and therapeutic studies. The clinical manifestation of Tourette syndrome can best be viewed along a continuum that includes both motor and behavioural features (Bruun & Budman, 1992; Robertson, 1989).

2.1.3 Etiology and pathogenesis

The etiology of Tourette syndrome, according to various prevailing views, is unknown (Barabas, 1988; Gedye, 1991; Shapiro *et al.*, 1978).

In his early writings, Gilles de la Tourette considered Tourette syndrome to be hereditary. For many years the etiology of Tourette syndrome was ascribed to psychogenic causes, and the importance of genetic factors was neglected.

Comings (1990) speculated that a single gene could be responsible for Tourette syndrome symptoms. However, no gene or suspected chromosome has yet been identified, and controversy continues among geneticists about how a single gene could be responsible for a range of behavioural manifestations from attention deficits to compulsive eating disorders (Merz, 1988). Unfortunately, many Tourette syndrome criteria have proven to be inaccurate, which has necessitated repeated changes in diagnostic criteria.

Recently, there has been an unexplained increase in the number of dual-diagnosis cases. Tourette syndrome has been reported to co-occur with another disorder, either with a known etiology, such as Down's syndrome and encephalitis, or with an unknown cause such as attention deficit hyperactivity disorder, obsessive-compulsive disorder, autism, schizophrenia and mental retardation with unknown cause (Comings, 1990; Gedye, 1991).

Furthermore, evidence for both familial and sporadic cases has been published (Barabas, 1988; Eldrige & Denckla, 1987; Kurlan, 1989; Pauls & Leckamn, 1986; Robertson, Trimble & Lees, 1988). In the late 70's investigators demonstrated that Tourette syndrome and chronic tics show familial concentration, and in families with Tourette syndrome, chronic motor tics appeared to present in a milder form of the same illness. Susceptibility to both Tourette syndrome and chronic motor tics is transmitted vertically from generation to generation, indicating a genetic influence (Bruun & Budman, 1992). Single-major-locus, polygenic and multifactorial patterns of transmission within families have been suggested. However, the most widely held idea of transmission patterns derives from a segregation analysis that was administered by Pauls and Leckman (1986) of 30 families affected by Tourette syndrome. The analysis indicated that the disorder is inherited in an autosomal dominant pattern (if a person had Tourette syndrome, each son/daughter has a fifty-fifty chance of inheriting the gene) with incomplete and sex-specific penetrances (affected

males are more common than affected females) and variable expression, including Tourette syndrome, chronic motor tics and obsessive-compulsive disorder. Further segregation and linkage studies by Price, Pauls, Kruger and Caine (1988) and Pauls, Pakstis, Kurlan, Kidd, Leckman, Cohen, Como and Sparks (1988) supported these autosomal dominant gene findings.

It is now generally accepted that most cases of Tourette syndrome are genetically determined (Kurlan, 1989). The recognition of a specific inheritance pattern for Tourette syndrome and the identification of significant kindred affected by the illness, have raised hopes that the application of pedigree analysis (diagrammatic presentation of a family history), using modern recombinant DNA technology, will be able to identify a genetic marker linked to the disorder (Comings, 1990).

However, there is consensus of opinion that Tourette syndrome is probably inherited by an autosomal single dominant gene, with variations of penetrance. There are some suggestions that the same gene can be expressed as an obsessive-compulsive disorder (Comings & Comings 1988; Pauls & Leckman, 1986). However, to date, there is no conclusive proof that the gene may be expressed as attention deficit hyperactivity disorder (Kurlan, Behr, Medved & Como, 1988).

In conclusion, Tourette syndrome is a diagnostic label for a disorder of presumably unknown etiology, which is lacking in biochemical/neurologic confirmation, or any specific known laboratory, electrophysiologic or radiographic features that are confirmatory or diagnostic. It relies solely on observable, yet changing clinical criteria (Barabas, 1988; Gedye, 1991).

There are many striking similarities between the behaviour of patients with Tourette syndrome and different aspects of frontal lobe dysfunction.

Researchers such as Denckla (1996), Comings (1990), Gedye (1991), Gorenstein *et al.*, (1989) and Rothenberger (1990) have commented on these similarities on various occasions.

2.1.4 Frontal lobe dysfunction

Researchers such as Mattes (1980) and Rosenthal and Allen (1978) have suggested an important association between the limbic system and the frontal lobes in patients with Tourette syndrome and related behaviour disturbances. The frontal cortex and its limbic connections (including the septum and the hippocampus) are considered particularly likely to be involved with tic and hyperactive behaviour found in Tourette syndrome patients. The main reasons are as follows: (1) Dysfunction of frontal-limbic structures has pronounced disinhibitory effects, including impulsiveness and distractibility (Luria, 1973; Numan, 1978); (2) The frontal-limbic system has important reciprocal connections with the reticular activating system, a presumed site of dysfunction in hyperactive children (Routtenberg, 1968); and (3) Physical immaturity of frontal-limbic structures in humans is associated with juvenile behaviour patterns similar to those observed in hyperactive children, such as those with Tourette syndrome and attention deficit hyperactivity disorder (Luria, 1973; Mesulam, 1986).

Gedye (1991) postulated an interesting hypothesis in which frontal lobe dysfunction is indicated in Tourette syndrome patients. The conclusion reached is particularly appealing because it accounts for the differences in Tourette syndrome diagnostic criteria, the dual-diagnosis cases, the difficulty in finding biochemical correlates for all cases, the difficulty in attributing a variety of disturbances to a single gene, and why some cases run in families, but others do not. Gedye made the following premises:

1. Tourette syndrome tics/ movements are involuntary.
- 2a. Tourette syndrome tics result from abnormal discharges in the frontal lobe(s) that cause innervation of numerous muscles.
- 2b. Duration and recurring nature of Tourette syndrome movements are similar to duration and recurring nature of involuntary movements during frontal lobe seizures.
- 2c. Neurologic studies report frontal lobe involvement in Tourette syndrome.
- 3 Numerous etiologies can result in frontal lobe epilepsy.
- 4 Etiologies known to cause frontal lobe seizures are reported as co-occurring with Tourette syndrome.

Based on these premises, Gedye's work indicated that abnormal discharges in the frontal lobes, particularly the motor area in the mesialbasal region, are the final common dysfunction that causes the diverse phenomena collectively labelled as Tourette syndrome.

Supporting Gedye's findings, numerous neurologic studies on frontal lobe seizures provide specific examples of involuntary facial, vocal and limb movements that are caused by dysfunction in the frontal lobes. All were related to neural disturbance in the motor strip localised in the mesial/mesibasal area of the brain (Waterman *et al.*, 1987). As there are several hundred muscles in the human body, it is understandable that the motor manifestations can be disparate from one patient to the next, or even in the same patient, from one occasion to the next (Shapiro *et al.*, 1988). Abnormal discharges in the frontal lobes are known to cause vagul nerve stimulation, which manifests in changes in respiration and blood pressure (Buchanan, Valentine & Powell, 1985). Thus, various breathing changes, plus the possible permutations of 56 vocal muscles can result in gasps, grunts, barks, and so on. Gedye (1991) and Waterman *et al.*, (1987) supported this, confirming that conjugated head and eye movements do occur owing to stimulation of the frontal cortical areas.

Furthermore, Rothenberger (1990) administered a study concerned with electrical brain activity registered prior to voluntary movement in children with Tourette syndrome, and compared the activity levels to those of healthy controls. Polygraphic electrophysiological recordings were carried out. He reported that, prior to the voluntary motion, children with Tourette syndrome shift their neuronal activity along the midline from a central brain region to a more frontal area. Whereas neuronal activity of the healthy controls was found to be concentrated in the central areas of the brain. Therefore it can be stated that an increase in hypermotor behaviour necessarily calls for more neuronal activity from frontal areas in order for Tourette syndrome patients to perform a voluntary act adequately.

To have a common site of dysfunction is not an etiology per se. Numerous etiologies can result in frontal lobe seizures (Mesulam, 1986; Rasmussen, 1975). Obviously different etiologies produce differences in the extent (localised trauma), type (neurochemical imbalance), and location of damage (orbital frontal, medial frontal). Given such variation in extent and type of damage, it is feasible that some cases might benefit from one medication, while others do not (Mesulam, 1986). Some Tourette syndrome cases show disturbances in many frontal cortical functions such as difficulty paying attention, planning, sequencing, changing set, obsessive-compulsiveness, and impulsiveness, which implies extensive damage. Others do not. Certain limbic involvement as previously mentioned, such as sleep and eating disturbances can occur in some cases, but not in others (Comings & Comings, 1988; Gedye, 1991; Mattes, 1980). Thus, the wide variety of etiologies that cause frontal lobe seizures accounts more readily for the heterogeneity in clinical presentation of Tourette syndrome than can a single-gene theory as previously speculated by Comings (1990).

Furthermore, researchers and neurologists have stipulated that an abnormal metabolism of dopamine and serotonin neurotransmitters normally found in the medial-prefrontal areas of the brain, cause this genetically transmitted disorder called Tourette syndrome (Chapman, 1994; Comings, 1990; Lakke & Wilmink, 1985; Mattes, 1980; Singer, Pepple, Ramage & Butler, 1978). In this regard, it is important to note that the dopamine-to-serotonin concentration ratio is of importance for motor activity. Increased dopaminergic activity is associated with an increase in, as well as with a higher frequency of abnormal movements, whereas serotonergic activity inhibits them. Thus, an equilibrium between these and other neurotransmitter systems such as the noradrenergic and cholinergic systems is important in the development of functions that include attention, emotional behaviour and complex psychomotor performance (Rothenberger, 1990). However, an imbalance of these neurotransmitters can lead to reactions in these frontal lobe areas that are either too quick or too slow, resulting in tics or impulsive behaviour (Denckla, 1996; Waterman *et al.*, 1987). Some Tourette syndrome patients have benefited from medication that increases serotonin, and others have benefited from medication that decreases dopamine, such as Haloperidol, thereby altering and possibly correcting an imbalance of one relative to the other (Mesulam, 1986; Singer *et al.*, 1978).

Furthermore, according to Comings (1990) when certain neuropsychological tests sensitive to frontal lobe dysfunction are administered to Tourette syndrome patients, two characteristics are often singled out. Firstly, their inability to construct a plan of action ahead of the act, to draw out a goal of action, to keep it in mind for some time (as an overriding idea), and follow it through in actions under the constructive guidance of such planning. Secondly, they may portray an inability to reprogramme an ongoing activity and to shift within principals of action whenever necessary.

However, Schultz (1999) and Denckla (1996) stipulated that it must be kept in mind that although proof of frontal lobe dysfunction in Tourette syndrome has been substantiated psychometrically on numerous occasions, results are unequivocal. The main reasons being that the frontal lobes are one of the most challenging areas of assessment, because of its interconnections with other regions of the brain, and that the structured test situations provided by conventional neuropsychological testing may actually mask the expression of deficits in this area.

2.1.5 Prevalence

The exact prevalence of Tourette syndrome is unknown. Recent estimates have ranged from 0.03 to 1.6%, and have been based on case series of patients referred for treatment, or on data obtained from questionnaires without clinical evaluations (Carrol & Robertson, 2000; Kurlan *et al.*, 1988). Systematic analysis of large Tourette syndrome families using a family study method in which all available family members are directly interviewed and examined, indicates that most cases of Tourette syndrome tics are mild and do not come to medical attention and that the disorder is often unrecognised and misdiagnosed by physicians (Kurlan, 1989). The environment in which the patients are diagnosed, such as well-structured consultation and clinic settings in which neurology and psychiatry patients are normally observed can also contribute to misdiagnoses (Lezak, 1995). This is often referred to as 'the doctor's office syndrome' (Comings, 1990, p.23) -- the patient may have severe tics and vocal noises, but once he enters the doctor's room they disappear. This suppressibility can also occur in a classroom situation, causing uninformed school psychologists/teachers to believe that there is nothing wrong with the supposedly Tourette syndrome child. In addition to the suppressibility of tics, erratic waxing and waning of Tourette syndrome symptoms makes evaluation and treatment difficult, often also resulting in misdiagnosis (Comings, 1990; Dornbush & Pruitt,

2000; Karch, 1997). Thus, previously reported rates for the prevalence of Tourette syndrome are likely to represent gross underestimates.

Furthermore, studies of the prevalence of Tourette syndrome have been restricted to an analysis of the tic disorder, and mounting evidence indicates that behavioural disorders, including obsessive-compulsive disorder and attention deficit hyperactivity disorder, may be the only clinical manifestations of illness for some individuals. Therefore, the prevalence of the disorder may be much higher than current estimates, especially if behavioural manifestations are included (Chase, Friedhoff & Cohen, 1992).

To conclude, the exact prevalence of Tourette syndrome is unknown, and currently accepted figures may be underestimated (Robertson, 1989).

2.1.6 Demography

Tourette syndrome is found in all cultures, racial and social groups, with the most case reports coming from the UK and the USA. A recent survey compiled by Carroll and Robertson (2000) documented findings from 3,500 Tourette syndrome cases in 22 countries including South Africa. Overall, it was found that the characteristics of Tourette syndrome were independent of culture, race or social class, and that the symptoms, tics and noises, are very similar, irrespective of the country of origin. However, most studies and reviews agree that Tourette syndrome appears 3 to 6 times more frequently in males than in females (Bruun & Bruun, 1994; Comings *et al.*, 1990; Kurlan, 1993; Leckman & Cohen, 1998; Shapiro *et al.*, 1988). Females, on the other hand, are more likely to display obsessive-compulsive symptoms without the related tics (Chase *et al.*, 1992).

Furthermore, Comings (1990) and Shapiro *et al.* (1988) stated that there is no evidence that any of the demographic or illness-related variables significantly

distinguish patients with Tourette syndrome from normal controls: parents' age at time of patient's birth, birth order, birth weight, history of abortions, parental complications, patient's medical history, or family medical history. However, other authors, Lees (1985), and Lucas and Rodin (1973) reported possible birth complications of 25% and 40% in their samples irrespectively.

2.2 Clinical features: A spectrum disorder

Lang (1992) emphasised the clinical heterogeneity of Tourette syndrome, which covers a broad spectrum of tic severity as well as behavioural disturbances. A developmental history of hyperactivity has been reported in more than half of the Tourette syndrome cases (Shapiro *et al.*, 1988). This is discussed in the following paragraphs.

2.2.1 The tic disorder

Tics are short, sudden, recurrent, purposeless, non-rhythmic, involuntary movements (motor tics or twitches) or sounds (vocal/phonic tics or noises) that occur out of a background of normal motor activity. Tic disorders present themselves on a continuum from mild to severe. Tics may be so mild that no one notices them, or they may be so severe that they disrupt the person's life and the lives of those around them (Kurlan, Behr, Medved & Como, 1988; Lees, 1985).

Both motor and vocal tics can be divided into two subcategories: simple and complex. Simple motor tics are the most characteristic type of tics and are symptomatic of all types of tic disorders. They usually involve one muscle group and produce one basic movement. Often, the first symptom is a rapid muscle spasm in a small area of the face around the eyes and mouth. After a short time, they may disappear never to return. Twenty to 25% of children have these tics at one time or another. Examples are eye blinking, squinting, rolling of the eyes,

head twitching or shoulder shrugging (Carroll & Robertson, 2000). Complex motor tics involve more than one muscle group, moving in a certain sequence. These tics may consist of a series of simple tics that follow in a stereotyped but meaningless repetitive sequence, such as touching the chin, touching the chest and shrugging a shoulder; touching the chin, touching the chest and shrugging a shoulder, or any other tics that are repeated in the same way each time. Furthermore, these tics may also consist of more co-ordinated and complicated movements that appear to be purposeful to those watching, when they really are not. Most often these tics start in the upper body and move down. Examples are bending over, snapping the fingers, pinching, spinning around while walking or pulling on clothing. Some patients may even hurt themselves without meaning to. For example, patients may snap their fingers so many times a day that they get blisters (Dornbush & Pruitt, 2000; Kurlan, 1993; Moe, 2000; Robertson, 2000).

Simple vocal tics consist of a variety of brief, inarticulate noises and sounds, such as throat clearing, grunting, coughing and excessive sniffing. These noises are made by tic-like movements of the vocal apparatus and have no meaning to the patient. Patients are often able to soften the sound of this tic or disguise it in some way. Complex vocal tics on the other hand are a bit more puzzling. They may consist of sounds turned into syllables, words, a series of words, phrases or even sentences. Some patients' sounds get very loud, even becoming explosive. In rare cases, the sound could become an obscenity or curse word (Bruun & Bruun, 1994; Carroll & Robertson, 2000; Moe, 2000). Sometimes the patient is able to change the bad word or phrase, so it sounds acceptable. For example, 'up yours' becomes 'oh, sores' (Moe, 2000 p.16).

Other more rare complex motor and vocal tics may occur with tic disorders. Complex motor tics may include copropraxia (making involuntary obscene gestures such as the V or middle finger signs), and echopraxia, or echokinesis

(imitation of another person's movements). Complex vocal tics may include coprolalia (inappropriate and involuntary uttering of obscenities or socially objectionable words or phrases). Coprolalia is also known as the swearing tic or the F-word tic. In many cases, as mentioned earlier, the patient may be able to change the bad word or phrase so that it sounds acceptable, but if not, this then becomes one of the most, if not *the* most, distressing and disabling symptoms of a tic disorder. Echolalia (repeating the last word or phrase of another person) and palilalia (repeating one's last word) also form part of the more rare complex vocal tics (Carroll & Robertson, 2000; Comings, 1990).

Recently more attention has been focused on sensory symptoms that may occur in Tourette syndrome, which generally are referred to as sensory tics. These tics can be defined as patterns of somatic sensations, which are essentially different from tics, and characteristically occur before tics. They are variously described by patients as feelings of pressure, tickling, warmth, cold or other abnormal sensation in skin, bones, muscles, and joints or, even just a generalised discomfort (Carroll & Robertson, 2000; Lees, 1985; Moe, 2000). These sensations are localised to specific body regions, such as the face, shoulder, or neck, and result in dysphoric feelings. To relieve the discomfort, the patients make a quick movement (tic). Other patients make noises in response to sensory stimulation in their throat or voice box (Kurlan, 1993; Shapiro *et al.*, 1988). Despite the fact that sensory tics have received relatively little attention, it seems that they are actually quite common (Bruun & Bruun, 1994; Cohen & Leckman, 1992).

Furthermore, characteristically, tics are reduced during sleep and are suppressible for varying periods of time, depending on the severity and the psychological and environmental factors. Some patients can suppress their tics for a few minutes while others can suppress them for most of the day. However, the longer the tics are suppressed the more the tension builds up and the more

need there is to release them at a later stage. Anxiety, anger, excitement, fatigue, physical illness and stress significantly increase symptoms, thereby reducing the ability to suppress tics (Dornbush & Pruitt, 2000; Gedye, 1991; Kurlan *et al.*, 1988).

The most severe form of tic disorder is Tourette syndrome. It represents a wide spectrum of involuntary motor and vocal tics, some of which may appear quite bizarre, such as throwing objects or pulling down pants, and can often be misdiagnosed as a manifestation of a psychological illness (Chapman, 1994; Dornbush & Pruitt, 2000) (refer to APA (1994) diagnostic criteria as previously mentioned). In addition to Tourette syndrome there are two other categories of tic disorders that are often misdiagnosed along with Tourette syndrome: Transient tic disorder (TTD) and Chronic multiple tic disorder (CTD). TTD is diagnosed when there are single or multiple motor and/or vocal tics that occur for at least four weeks, but not for longer than 12 consecutive months. The onset of the tics must be before the age of 18 years (APA, 1994). CTD involves chronic motor tics or chronic vocal tics, but not both, lasting longer than one year. The onset of the tics must be before the age of 18 years (APA, 1994). Chronic multiple tic disorder is seen as a mild form of Tourette syndrome and is also believed to be a genetically transmitted disorder (Cohen, 1988; Moe, 2000).

2.2.2 Associated behavioural disturbances

Although chronic, multiple motor and vocal tics are usually the most prominent clinical features of Tourette syndrome, and represent the signs upon which the diagnosis of the disorder is currently based, tics may also be accompanied by a variety of behavioural disorders. These include attention disorders such as Attention deficit hyperactivity disorder (ADHD) and Attention deficit disorder (ADD), obsessions and compulsions disorders diagnosed as Obsessive-compulsive disorder (OCD), learning disorders (LD), various social and emotional

behavioural problems as well as sleep disorders (Bruun & Bruun, 1994; Golden, 1984). However, the most common related disorders are attention and obsessive-compulsive disorders.

(1) Attention deficit hyperactivity disorder and attention deficit disorder

On average about 40 to 50% of Tourette syndrome cases are diagnosed as having a strong presence of attention deficit hyperactivity disorder or attention deficit disorder, thus making it the most common symptom after motor and vocal tics (Comings, 1990; Du Toit, 1986; Leckman & Cohen, 1998). Manifested by inattention, impulsiveness and hyperactivity, these attention disorders often have a far more disruptive impact on the life of the Tourette syndrome patient than the tics. They may show bad social adjustment and poor academic achievement such as poor organisation, short attention span, restlessness, distractibility, and a tendency to intrude and interrupt others (Shapiro *et al.*, 1988).

The relationship between attention deficit hyperactivity disorder and Tourette syndrome has been studied extensively by Comings and Comings (1988). They state that attention deficit hyperactivity disorder symptoms precede the onset of tics by an average of 2.5 years, reach a maximum severity at about 10 years of age, and gradually recede through the adolescent years and early twenties. Unfortunately, in most cases it is extremely difficult to pinpoint the onset of attention deficit hyperactivity disorder symptoms. However, as previously stated, there is a general consensus that the majority of Tourette syndrome patients will have these symptoms.

(2) Obsessive-compulsive disorder

Other than motor and vocal tics and attention disorders, obsessions and compulsions are the most frequent behavioural manifestations of Tourette syndrome (Moe, 2000).

Obsessive-compulsive disorder is characterised by persistent obsessions (recurrent, intrusive, senseless thoughts) or compulsions (repetitive and purposeful behaviours, which are performed according to certain rules or in a stereotyped fashion). They are a significant source of distress to the individual and/or interfere with the individual's functioning, and normally exceed one hour per day (Lees, 1985; Moe, 2000; Schultz, 1999).

According to Comings (1990) obsessive-compulsive behaviours have on various occasions been reported in 30 to 90% of individuals with Tourette syndrome. However, reports have also been found of a high frequency of tics in patients with a primary diagnosis of obsessive-compulsive disorder. Often the patient had either a personal history of tics or a family history of tics (Pitman, Green, Jenike & Mesulam, 1987). In general, various studies measuring the relationship between tic severity and obsessive-compulsive symptoms have proved the following: Obsessions often contribute to the prediction of learning problems, perfectionism, and antisocial behaviour; compulsions contribute to the prediction of hyperactivity, psychosomatic problems, perfectionism and muscular tension (De Groot, 1995; Robertson, 2000).

(3) Learning disorders

Statistics show that up to 60% of children with Tourette syndrome have certain learning disabilities in spite of the fact that they normally have an average or above average intelligence. The areas often affected are reading, writing, mathematics and visuomotor integration (Du Toit, 1986; Karch, 1997; Kurlan, 1993), whereas visuomotor integration (the ability to copy accurately either

simple and/or complex geometric designs and figures, when asked to do so) has been found to be the most affected area of dysfunction for Tourette syndrome patients (Bruun & Bruun, 1994; Dornbush & Pruitt, 2000; Schultz, 1999).

The affected areas mentioned above may all be interrelated to another main problem area of Tourette syndrome patients, namely, that of executive function dysfunction. This refers to those abilities needed for problem solving and is often related to the prefrontal and frontal areas of the brain. Among these are attention and concentration, drive and motivation, cognitive/mental flexibility, planning and organisational skills, ability to recognise and correct mistakes, ability to respond to feedback cues, and the ability to understand the consequences of behaviour (Rothenberger, 1990). Various school and education related studies by Comings, Himes and Comings (1990), Fischer *et al.*, (1990) and Pineda *et al.*, (1999) have implicated abnormal executive functioning in Tourette syndrome patients/pupils. Furthermore, studies utilising neuropsychological tests of frontal lobe dysfunction have shown a relationship between executive dysfunction and Tourette syndrome, thus confirming these findings (Denckla, 1996; Schultz, 1999).

(4) Behavioural and co-morbid conditions

Part of the definition of Tourette syndrome is that the tics wax and wane in severity. However, in addition there may also be marked waxing and waning of mood, confrontational and oppositional behaviour such as rage attacks, periods of bizarre behaviour, and general irritability (often referred to as oppositional defiant or conduct disorders). Cycles can vary from minutes to hours, days, months or years. These cycles may be a reflection of the same susceptibility of gene carriers of manic-depressive disorder (Comings, 1990). Depression, however, has been shown to be quite common in both adult and juvenile Tourette syndrome patients, although studies often only examine depressive

symptomatology such as aggression, obsessions and hostility rather than the depressive illness itself. Thus, more studies in this area still have to be undertaken (Cohen & Leckman, 1998; Golden, 1984).

Other behavioural symptoms that may occur in Tourette syndrome are inappropriate sexual behaviours such as sexual touching, an excessive preoccupation with sex, compulsive masturbation or exhibitionism. Addictive behaviours including alcoholism, compulsive eating, shopping and gambling might also present with Tourette syndrome (Robertson, Trimble & Lees, 1988). Furthermore, in a retrospective review, Robertson (2000) found that Tourette syndrome patients (both adults and children) had significantly more anxiety than did healthy normal control individuals without Tourette syndrome. Specific diagnoses that were found included severe anxiety, generalised anxiety disorder, panic disorder, separation disorder and phobias (Carroll & Robertson, 2000).

(5) Sleep disorders

Sleep disorders are common in Tourette syndrome patients (Kurlan, 1993, Moe, 2000). It has been suggested that sleep disturbances in Tourette syndrome are indicative of a disorder of arousal. Researchers reported an increase in sleep stages three and four on electroencephalogram (EEG) readings (high-voltage rhythmic, delta waves), thus suggesting that Tourette syndrome is a disorder of arousal (Rothenberger, 1990). The abnormalities of sleep that are frequently reported include insomnia (trouble getting to sleep), early awakening, sleepwalking and disorders of arousal such as night terrors (severe nightmares) and enuresis (bedwetting) (Glaze, Frost & Jankovic, 1982; Lucas & Roden, 1973; Rothenberger, 1990).

To conclude, it is important to note that according to Bruun and Bruun (1994) there is a considerable amount of controversy over how commonly these

behaviours/ conditions are associated with Tourette syndrome. Some Tourette syndrome researchers found a high incidence of behavioural difficulties, and others found their patients to be generally unaffected by these problems, thus contributing to the controversy.

2.3 Conclusion

Tourette syndrome is a complicated condition; it can involve many associated behaviours and varied etiologies. From the preceding discussion it is clear that Tourette syndrome has heterogeneous symptoms and these symptoms could have executive function components. In the following chapter a theoretical overview of executive function is discussed.

CHAPTER 3

THEORETICAL OVERVIEW: EXECUTIVE FUNCTION AND THERAPEUTIC HORSE RIDING

3.1 Executive function

Executive function is often said to have the most complex involvement in human cognitive behaviour and is seen as very complex.

3.1.1 Definition of executive function

When formulating executive function, 'self-structure' can be seen as the most important component of accomplishment for an individual (Goldstein & Green, 1995). Functions related to self-structure include various loosely related higher-order cognitive processes such as: initiation, planning, hypothesis generation, cognitive flexibility, decision making, regulation, feedback utilisation, judgement and self-perception/self-monitoring necessary for conceptual appropriate behaviour – overall organisation and control of conscious activities. Executive functioning is normally related to the prefrontal regions of the brain, but deficits/impairments are not always localised to these areas. They may also occur in the context of dysfunction in other brain regions and should always be considered in that light (Denckla, 1996; Du Toit, 1986; Lezak, 1995; Spreen & Strauss, 1998).

3.1.2 Conceptual components of the executive functions

According to Lezak (1995) the executive functions can be conceptualised as having four components: volition, planning, purposive action and effective performance. –Volition is the complex process of determining what one needs or wants, and being able to conceptualise some kind of future realisation of that need or want. In short, it is the capability for intentional behaviour (e.g., formulation of goals, motivation, and self-awareness). Planning is the identification and organisation of the steps and elements (e.g.,

skills, material, and other people) needed to carry out an intention or achieve a goal. Purposive action refers to the translation of an intention or plan into productive, self-serving activity, and requires a person to be able to initiate, maintain, switch, and stop sequences of complex behaviour in an orderly and integrated manner. For effective performance - a performance is as effective as the performer's/person's ability to monitor, self-correct, and regulate the intensity, tempo and other qualitative aspects of action.

Each component involves a distinctive set of activity-related behaviours, and all are necessary for appropriate, socially responsible and effectively self-serving human conduct. However, it is rare to find a patient with impaired capacity for self-direction or self-regulation, who has defects in only one of these features of executive functioning. Rather, defective executive behaviour typically involves a cluster of deficiencies of which one or two may be especially prominent. Keeping this in mind when focusing on Tourette syndrome and its possible relation to these components, it seems that planning, purposive action and effective performance could be affected.

To conclude, executive functions can break down at any stage in the behavioural sequence that makes up planned or intentional activity. Systematic examination of the capacities that enter into the four aspects of executive activity will help to identify the stage or stages at which a breakdown in executive behaviour takes place. Such a review of a patient's executive functions may also bring to light impairments in self-direction or self-regulation that would not become evident in the course of the usual examination or observation procedures. Examination procedures are normally very structured, and executive function tests require a patient to show how well he or she can structure the situation, which may rather complicate matters when the structure required has to be self-initiative without guidance from the examinee (Frederiksen, 1986).

3.1.3 Assessment of the executive functions

The assessment of the executive functions is one of the most challenging tasks facing clinicians involved in the evaluation of behaviour (Benton, Hamsher, Varney & Spreen, 1983; Lezak, 1995; Luria, 1980; Mapou & Spector, 1995; Spreen & Strauss, 1998).

Although there are numerous neuropsychological measures to examine executive function, no single test can capture the full complexity. The tests may be interrelated to other areas of the brain, which are not purely focused on executive function, thus the question should always be asked: Which areas of the brain are involved in which functional systems? Furthermore, although deficits in problem solving and executive function are frequently associated with frontal lobe injury, they are not localised to the frontal lobes in the same way that we conceptualise sensorimotor or language localisation. Assessment should not be committed to finding evidence for or against frontal lobe damage, but should evaluate the level of functional abilities in and of themselves (Mapou & Spector, 1995).

Self-structure is an important component of executive function, and the structured test situation provided by conventional neuropsychological testing may actually mask the expression of deficits in this area, thus complicating the assessment of goal-orientated and planned behaviour. Therefore, in this assessment situation, more than in any other, one must elicit history of, and even observe the patient's level of function in his or her natural environment (Goldstein & Green, 1995). This motivated the use of the Lahey Child Behaviour Checklists that were completed by the participant's parents to evaluate certain behavioural aspects qualitatively. (Further detail on this checklist follows in chapter 4.)

The skills necessary for performing behaviours such as planning, hypothesis testing and self-monitoring are interrelated and often subtle. Successful performance does not only depend on the integrity of these specific skills, but also on other more elemental cognitive abilities such as language, attention, and memory, which should preferably be relatively intact. The ability to use

feedback, for example, may be disrupted because the patient has forgotten a previous response rather than being insensitive to environmental influences. Thus, one should always interpret executive impairments in the light of other cognitive abilities. This is also important when evaluating the executive functions of Tourette syndrome patients, because vocal and motor tics and related hyperactive or obsessive-compulsive behaviours, as previously discussed, can have an influence on their language and attention performance, and therefore must be taken into consideration. Furthermore, the motivational level of the patient also influences whether he or she is willing to formulate strategies and to select behaviours necessary to achieve goals. Thus, assessment requires a comprehensive approach, which employs a variety of methods and includes careful analysis of underpinning impairments (Benton *et al.*, 1983; Frederiksen, 1986; Goldstein & Green, 1995).

Commonly used assessment techniques for the evaluation of executive function that portray sensitivity to frontal lobe dysfunction are as follows:

Psychometric test	For assessment of
Wisconsin Card Sorting Test (WCST)	The ability to form abstract concepts, to shift and maintain set, and utilise feedback, thus providing information on several aspects of problem-solving behaviour beyond basic indices such as task success or failure (Drewe, 1974; Heaton, Chelune, Talley, Kay & Curtiss, 1993; Spreen & Strauss, 1998).
Trail-Making Test A & B	Selective attention and cognitive shift abilities. In other words it requires attention and an ability to switch plans and withhold inappropriate responses (Abraham, Axelrod & Ricker, 1996; Lezak, 1995; Spreen & Strauss, 1998).
Stroop Colour Word Test	The ease with which a person can shift his or her perceptual set to conform to changing demands and suppress a habitual response in favour of an unusual one (Aloia, Weed & Marx, 1997; Lezak, 1995; Spreen & Strauss, 1998).

Rey-Osterrieth Complex Figure Test (CFT)	Visuospatial constructional ability and visual memory. It is also very helpful in assessing organisational strategies. Other cognitive processes such as planning, problem-solving strategies, as well as perceptual, motor, and memory functions are also assessed by this test (Lezak, 1995; Mapou & Spector, 1995; Spreen & Struass, 1998).
Porteus maze test or alternatively Tower of London test	The patient's ability to inhibit impulsive tendencies and to consider the future consequences of his or her behaviour toward the achievement of a goal. In other words, the patient's capacity to look ahead and to think through a number of response alternatives (Lezak, 1995; Mapou & Spector, 1995; Porteus, 1965).
Controlled Oral Word Association Test (COWAT) or word fluency test	Divergent thinking (the ability to produce alternative approaches, which is critical to problem solving) (Benton <i>et al.</i> , 1983; Mapou & Spector, 1995; Spreen & Struass, 1998).

Characterisation and measurement of executive function deficits remain a major challenge in the field of neuropsychology. Although numerous clinical and experimental techniques have been developed, it is important to bear in mind that very few have been shown to have a high degree of sensitivity and specificity with regard to characterising executive function defects and related frontal lobe dysfunction.

3.1.4 Frontal lobe involvement

The frontal lobes have been regarded as the cortical locus of 'higher learning' and sometimes as the structures that define the self (Goldstein & Green, 1995). These lobes comprise about one-third of the human neocortex and are the most recently developed part of the cerebrum. Their principal roles are the regulation of ongoing behaviour, planning and maintenance of goals, the latter referred to as the executive functions. The specific portion of the frontal lobes responsible for maintaining these cognitive behaviours is known

as the prefrontal cortex. It is also thought to play a part in regulating social behaviour and personality (Denckla, 1996; Gorenstein *et al.*, 1989; Luria, 1980; Martin, 1998).

Lesions of the frontal lobes tend not to disrupt cognitive functions as obviously as post-central lesions. Rather, frontal lobe damage may be conceptualised as disrupting mutual relationships between the major functional systems – the sensory systems of the posterior cortex, the limbic-memory system with its interconnections to the subcortical regions involved in arousal, affective and motivational states, and the effector mechanisms of the motor system (Levin, Eisenberg & Benton, 1991). Neuropsychological features of frontal lobe dysfunction could include the inability to behave spontaneously, the inability to plan, form strategies and execute these strategies effectively, an inability to shift response strategy, a failure to maintain attention, the unprompted utilisation of objects in the environment, poor free memory recall and impaired working memory (Martin, 1998).

However, the frontal lobes perform the highest levels of integration in the brain and act as the central processor for information coming in from the senses. Along with the limbic system (the part of the brain that controls one's emotions), the frontal lobes make plans for action, which are passed on to the motor areas. The frontal lobes contain the association cortex, which controls all other lesser association regions. When the frontal lobes don't function effectively, there is a major impact on the ability to pay attention, to make plans and to change plans. Reactions become thoughtless and impulsive. There may be no motivation to make plans or if made they may be quickly abandoned. Thus, optimal behaviour requires an all output optimal functioning frontal cortex in conjunction with the limbic system (Denckla, 1996; Luria, 1980; Waterman *et al.*, 1998). These functional links between the limbic system and the frontal lobes are described in research compiled by Mattes (1980) and Rosenthal and Allen (1978) on Tourette syndrome as discussed previously.

Furthermore, frontal lobe dysfunction involves how a person responds, which can certainly affect the what, the content of the response. Frontal lobe patients' failures in neuropsychological test results are more likely to result from their approach to problems than from lack of knowledge or from perceptual or language incapacities. They often demonstrate accurate perception and facility and accuracy in naming or writing, but get stalled in carrying out all of an intentional performance. The latter neuropsychological features can also be related to frontal lobe dysfunction in Tourette syndrome patients as discussed previously. Dissociation between what patients say or appear to see, and what they do or seem to feel has lately also drawn attention to frontal lobe dysfunction (Lezak, 1995).

3.1.5 Luria's theory

The famous Russian neuropsychologist Aleksandr Romanovich Luria's systems theory of functional organisation of the brain has largely contributed to the defining of executive functioning, specifically because of his contribution to our understanding of the function of the frontal lobes.

In brief, Luria viewed the frontal lobes as a tertiary zone, which allows an individual to plan and organise behaviour. Similar to Luria's theory is Norman and Shallice's supervisory attentional system, which views the frontal lobes as reflecting the activity of contention scheduling (controls the execution of actions) and a supervisory attentional system (provides conscious attentional control needed to change behaviour). Inadequate control leads to frontal lobe dysfunction (Martin, 1998). Various other theorists such as Goldstein, Mesulam and Milner in Rains (2001) have also contributed to this field of study. They conceptualise frontal and prefrontal lesions as having the effect of a disorder of attention or reasoning and planning. This they regard as the result of an impairment in the initiation and spontaneous activation of behaviour, or the inability to grasp the essence of a situation and utilise a past experience to regulate behaviour through one's own or another person's

verbal instruction. However, this study is based on Luria's theory, which explains certain frontal lobe dysfunctions related to Tourette syndrome.

According to Luria (1980) the brain is functionally divided into three basic units. Unit one (the upper and lower brainstem and reticular formation) regulates the arousal/energy level of the cortex as well as the maintenance of proper muscle tone. Unit two (parietal, temporal and occipital regions) plays a key role in the reception, integration and analysis of sensory information from both the internal and external environment. Unit three (the frontal and prefrontal lobes) is the executive of the brain and is involved in planning, executing, and verifying behaviour – overall organisation and control of conscious activity. All behaviour is regarded as the product of groups of brain areas working together as a functional system, each part of the system making a specific contribution to the functioning of the system as a whole. The type of symptoms a person may display will depend on which part of the functional system has been compromised.

With regard to Tourette syndrome, the following contributions of frontal and prefrontal lobe dysfunction, observed by Luria in Comings (1990) are of main interest:

Initiation of programmes and attention	The formation of intentions and programmes, and the regulation and verification of the most complex forms of behaviour.
Speech	The planning, programming and initiation of actions - a requirement for speech.
Speechless apathy	The higher order function of the initiation of action is severely impaired. These patients usually lie completely passively, express no wishes or desires and take no necessary action. However, this is not a cessation of all behaviour since they may join in a conversation between other people.
Echo movements	Echopraxia - a variation of picking up on an action initiated by others or the imitation of another person's movements.

Perseveration	The inability to change a course of action with the result that the same movements, behaviour, or words are repeated over and over.
Problems with complex programmes	An example would be if a patient were asked to raise his hand, which he initially did, but was unable to sustain the movement and soon dropped his hand. If his hand was first placed under a blanket, so that a much more complex set of actions was necessary, he could not carry out the movement.
Problems with complex memory	Normal individuals can memorise a list of many nouns after several practice rounds, each of which adds some additional words until they are all memorised. However, in frontal lobe lesions, instead of progressively increasing, the number of retained words remains at around four – perseveration causes problems with these complex recall tasks.
Problems with complex arithmetic	Although simple addition and subtraction cause no problems, frontal lobe lesions result in difficulties with more complex arithmetic, which involves the need to hold some intermediate results in the mind. For example, the request to successively subtract 7 from 100 may result in perseveration on the first answer 93...83...73.

It is interesting to note that this theory is currently being revised. It has been restructured and expanded by updating and elaborating on stimuli, task selection and instructions for existing measures. Executive and memory functioning measures have been updated, and measures of attention have been added; also included are theories of personality and emotion (Chistensen, 2003).

Luria concluded that in humans the frontal lobes participate directly in the state of increased activation, which accompanies all forms of conscious activity. It is the prefrontal lobes that evoke this activation and enable the complex programming, control, and verification of human conscious activity,

which require the optimal tone of cortical processes to take place (Comings, 1990).

3.1.6 Summary

When considering executive function or the evaluation their of, one should always be aware of possible subtle failures in reasoning, or roundabout ways of problem solving that may signal impairments, even if the scores on neuropsychological tests are normal. Moreover, neuropsychological testing is considerate of these limitations and sensitive to the complexities of the highest of the higher cortical functions (Levin *et al.*, 1991).

3.2 Therapeutic horse riding

The therapeutic value of horse riding has been known since the days of the ancient Greeks, and was described by Hippocrates as 'The Riding's Healing Rhythm' (Mayberry, 1978, p.47).

3.2.1 History

The value of horse riding for the physically disabled has been known since 1875, when Chassingne, a physiotherapist, noted that, as a result of the riding experience, the rider's balance was improved, muscles were strengthened, joints became more supple, and there was a marked improvement of the rider's morale (Bertoti, 1988). However, Tissot in 1782 was one of the first physicians to regard riding as beneficial to general health (Riede, 1988; Detlev, 1988). Since then it has been reported that many people with various disabilities have benefited in different ways from horse riding (Britton, 1991; Davies, 1988; Bertoti, 1988; Haskin, Erdman, Bream & MacAvoy, 1974; Joswick, 1983; McKinnon, 1995; Renaud, 1982; Walsh, 1989). Some people with lesser disabilities could report in their own words on the positive effects of horse riding (Britten, 1991; Riede, 1988). Riginald Renaud in Walsh (1989) refers to an endocrine effect in quadriplegics after horse riding,

because they experienced it as a risky sport and the patient dismounting from a successful ride is therefore flushed with success and tremendous euphoria.

One of the first and most inspirational rehabilitations on horseback was Madame Liz Hartel, who in 1952 won a silver medal in dressage at the Olympic Games in Helsinki, when women were competing with men on equal terms for the first time. For Madame Hartel the terms were not equal, as she was still suffering from the effects of polio, which she contracted as a young woman, yet she showed the world what she was capable of achieving (Britten, 1991; Hasken *et al.*, 1974).

3.2.2 Definition of therapeutic horse riding

When defining therapeutic horse riding, one refers to a therapy administered by physiotherapists, occupational therapists and/or psychologists, where the horse plays an important role in the therapy situation. The three-dimensional movement of the horse's back stimulates and manipulates areas of the patient's body and consequently can improve some of its functions and abilities.

Therapeutic horse riding can be subdivided into three categories:

- Hippotherapy: The horse is the therapist - the three-dimensional movement of the horse's back is used as an apparatus to manipulate the passive patient's body. Certain functional activities, such as learning to clean, care for and groom the horse, are also part of the therapy.
- Remedial riding and vaulting: This therapy basically involves doing gymnastics on a horse. Cognition plays an important role and people with emotional instabilities are treated in this way. Motivation, self-esteem and social skills are often associated with this category.
- Riding for the disabled: In this form of therapy the rider is actively involved in manipulating the horse. The rider works towards the goal of independent riding, often resulting in the riders participating in competitive sport.

All three of these categories of therapeutic horse riding often share benefits such as improved general health and well-being, increased fitness, greater confidence, independence and a sense of achievement (Britton, 1991; Davies, 1988; MacKinnon, 1995). Thus, it is important that these forms of therapeutic horse riding should not be isolated from each other, but should be viewed as transcendent and complete therapies (Delius, 1998).

3.2.3 Equi-therapy

As previously mentioned, numerous studies have indicated the therapeutic value of horse riding.

Biery and Kauffman (1989), and Joswick (1983) have suggested improvement in balance, muscle strength and joint range of motion, which may lead to improved co-ordination. Bertoti (1988) indicated statistically significant improvements in posture, while subjective improvement was observed in self-confidence, muscle tone, weight bearing and sitting balance.

Furthermore, studies showed that participation in a therapeutic riding programme has potentially positive effects on psychosocial benefits such as self-confidence, self-concept, self-esteem, motivation, attention span, spatial awareness, concentration, listening skills, interest in learning and verbal skills (Basile, 1997; MacKinnon, 1995; Mayberry, 1978).

It is interesting to note that very little research has been done on therapeutic horse riding in South Africa, and to date only one registered study has been found, by Rufus (1997). Her main focus was to measure the influence of therapeutic horse riding on the self-concept of learning disabled children. Her results found enhancement in self-concept as well as overall improved riding ability.

With regard to Tourette syndrome and especially the measurement of executive functioning, no studies could be traced. However, a study by Basile (1997), administered in Louisiana, North America assessed the influence of therapeutic horse riding on behaviour (specifically impulsiveness and attention span) and self-esteem of attention deficit hyperactivity disorder patients, a behavioural disorder that's known to be interrelated with Tourette syndrome as mentioned previously. The results of her study did not show significant improvement due to various limitations such as a restricted population, incorrectly diagnosed participants, the use of inappropriate instruments to measure identified behaviours and an inadequate research design. Although some differences towards improvement in the targeted behaviour was noted through direct observation.

However, the focus has seldom been on why and how these functions actually improve physically and mentally. Equi-therapy as a new form of therapeutic horse riding addresses this improvement at a neurophysiological level.

3.2.3.1 Theoretical principles

The main focus of Equi-therapy's success is related to the stimulation of the vestibular system through sensory integration in the brain.

The vestibular system is situated in the inner ear and has three semi-circular canals, which are filled with endolymph or fluid. These canals are sensitive to movement and the movement of horse riding in particular activates these canals, distributing certain sensory inputs to the rest of the brain, promoting vestibular stimulation.

According to one of the leading pioneers of the concept of sensory integration, Dr. Jean Ayres, all our senses have to work together in concert. In other words, our senses of touch, smell, taste, sight and sound, as well as our physical movement and body awareness, all have to work in harmony. Thus,

sensory integration is the process of organising and processing sensory impressions for the brain to create useful body reactions/movements and perceptions as well as a reaction with feelings and thoughts. The sensory integration sorts, organises and combines all of the individual's sensory impressions into a complete and extensive brain function (Ayres, 1979). It can be understood as an interaction and co-ordination of functions and processes in the brain and between the individual and his or her environment. The adaptive reactions (associations between senses) are responsible for learning and experience, and are the basis for the development and maturation of the brain (Delius, 1998).

Ayres (1979) and other researchers such as De Quiros and Scragger (1978), Gregg, Haffner and Korner (1976), and Norton (1975), stipulate that through stimulation of the sensory system, the vestibular system plays a major role in the functioning of the brain as a whole, aiding postural responses, visual attention, and language development. The spinal column, brain stem, cerebellum, and cerebral hemispheres are particularly responsible for sensory reception, and influence awareness, perception and knowledge, movement, body posture, co-ordination of emotions, thoughts, memories, and academic learning. The vestibular core receives information from the muscles, joints (proprioception), skin (tactile), visual and auditory receptors, and from other sensory areas in the brain (the rest of the brain stem, the cerebellum and other areas of the cortex). The inhibition and facilitation of vestibular impulses occur simultaneously. If this does not function correctly, it results in a confusion of stimuli, which in turn diminishes our learning process and reduces our quality of living.

For some children, sensory integration develops effortlessly during the course of ordinary play and childhood activities. But for others, sensory integration develops in a disordered manner, causing a number of problems in learning, development and behaviour. In relation to this study, focusing on the stimulation of the vestibular system through therapeutic horse riding and Tourette syndrome children with their related behavioural problems such as

the attention disorders mentioned above, Dr. Ayres (1979) in her book, *Sensory Integration and the Child*, states the following: 'Well-modulated vestibular activity is very important for maintaining a calm, alert state. The vestibular system also keeps the level of arousal of the nervous system balanced. An underactive vestibular system contributes to hyperactivity and distractibility because of the lack of its modulating influence' (p.128). Thus, through administering equi-therapy, a possible improvement from an underactive to an overactive vestibular system could be expected.

It is interesting to note that a similar method of stimulation of the vestibular system exists, which has achieved numerous positive results, except that it focuses on sound stimulation rather than the movement of the horse as with equi-therapy. This method is the Tomatis method (also known as audiopsychophonology), which is a system of sound stimulation and audio-vocal training, to improve the functioning of the ear, especially as it involves listening, understanding and communication. The main focus of this method is to regulate the vestibular function, desensitise bone conduction and to make a person right ear dominant. Various conditions such as attention deficit disorder, attention deficit hyperactivity disorder, autism, Asperger's syndrome, pervasive development disorder, Down's Syndrome and learning delays have shown positive results. Specific areas of function that have been influenced are balance and co-ordination, sensory integration, gross and fine motor skills, visual processing, auditory processing, attention, speech and language (Sollier, 2003).

Thus, dysfunctional sensory integration means that the brain cannot organise the flow of sensorial impulses effectively, with the result that the person does not receive the correct information regarding his or her environment that is necessary to respond adaptively and develop normally. According to Ayres (1979), a person, be it an adult or a child, with sensorial integration problems shows greater difficulties with motor planning and with the execution of tasks that require reasoning and intellectual capabilities, which can be linked to possible frontal lobe (executive) dysfunction. These areas of the brain are

known to be the centre of interconnections and feedback loops between major sensory and major motor systems, linking and integrating all components of behaviour at the highest level (Lezak, 1995). This supports Luria's systems theory as previously discussed. It explains why dysfunction of unit 2 of the brain function which is responsible for sensory input, integration and coding in relation to unit 1 responsible for arousal and attention and unit 3 responsible for behavioural planning and execution make it difficult for the three units to function together as a system (Luria, 1980). Moreover, learning problems/disabilities in children or adults are caused by poor sensorial integration (Ayres, 1979).

In conclusion, this new form of horse riding therapy, which focuses on the stimulation of the vestibular system through sensory integration, uses planned activities on the horse to promote the various sensory systems and the way they work. This refers to the vestibular, proprioceptive, tactile, visual and auditory systems in particular. Activities using certain apparatus such as weights or balls and whistles are administered, which focus on improvement of specific areas of function such as balance, spatial perception, hemispheric integration, speech, language, muscle tone, motor planning and activity, auditory perception, vision, academic performance and active behaviour. These stimulating activities together with the three-dimensional movement of the horse act as a sort of double therapy.

3.2.4 Summary

Horse riding is a pleasurable activity for many people. It is a social skill that can be great fun for all involved. It is also an escape for many children and adults with disabilities, who might otherwise be confined to a wheelchair. For many, it provides mobility, allowing them to get from one place to another, but it is also much more than that. There is a different aspect to riding, one that most riders would never think of, and that is its therapeutic benefits, and how it can help individuals with vestibular stimulation and in their general health. These benefits are addressed by the administration of equi-therapy.

3.3 Conclusion

From the previous discussions, it appears that frontal lobe dysfunction could underlie the behavioural symptoms of Tourette syndrome patients. Thus it could be linked to the neuropsychological ability of these patients. Equi-therapy is known to improve vestibular stimulation through sensory integration in the brain, hence one can hypothesise that Tourette syndrome children characterised with executive dysfunctions could possibly benefit from this therapy. In the following chapter the research methodology used to evaluate the influence of equi-therapy on the executive functions of Tourette syndrome children is discussed.

CHAPTER 4

METHODOLOGY

4.1 Introduction

The aim of this study was to compare two groups of Tourette syndrome patients. A neuropsychological test battery would be used to evaluate components of executive functioning, before and after a therapeutic horse riding intervention. The first group was subjected to the horse riding intervention whilst the second, over the same period was not. However, following that period the second group also participated in the intervention. Thus, the two groups were compared with regard to their executive function performance on the tests, firstly as individuals and then in relation to each other.

In this chapter the methods used in this study are discussed. First the research design is discussed, including the selection of the participants and the procedure of the study. This is then followed by the data analysis and individual discussions of each instrument (neuropsychological test) used.

4.2 Research design

The research setting and circumstances in which this research occurred made it difficult to employ a true experimental design. Thus, for the purpose of this study a non-equivalent control group quasi-experimental design was implemented. In this design two pre-existing groups are used as an experimental and a control group, respectively. The participants are assigned to these groups non-randomly and are measured before and after the intervention. If the experimental and control groups do not differ in terms of the premeasure, but do differ in terms of the postmeasure, the difference in the postmeasure can with some certainty be ascribed to the intervention received (Rosnow & Rosenthal, 1996; Welman & Kruger, 2000).

4.2.1 Participants

The study consisted of 8 Tourette syndrome children between the ages of 9 and 15 years. They had been referred by several neurologists and paediatricians in the Pretoria and Johannesburg area, who had diagnosed the disorder according to the DSM-IV classification for the syndrome. It is important to note that participants referred were diagnosed with Tourette syndrome without related behavioural disorders such as attention deficit hyperactivity disorder or obsessive-compulsive disorder. However, these factors were considered when their test performance was evaluated after natural observation of the children's behaviour during the course of the study, as well as through the inputs received from their parents, who completed child behaviour checklists before and after the intervention.

Participants had to meet the following criteria for inclusion in the final sample:

- a) A definite Tourette syndrome diagnoses, (DSM-IV)
- b) Accessible geographic location,
- c) Fluency in written and verbal English or Afrikaans,
- d) A medical history free of additional ailments that may have an effect on performance tasks.

All other additional new therapies had to be delayed over the period, although medication already in use could be continued. However, parents had to inform the researcher if changes had to be made to the children's medication during this period, so that it could be noted in the possible effect on their test performances.

Owing to the selection method, participants were not matched for age, sex, socio-economic class, and so on. However, as previously discussed, boys are 3 to 6 times more likely to display Tourette syndrome symptoms than girls, thus the chance of boys being included in this research study was much higher than for girls diagnosed with Tourette syndrome, which was the case in this study.

To conclude, because of these criteria and the low prevalence estimates of diagnosed Tourette syndrome patients, discussed above, sample sizes were small.

4.2.2 Procedure

The research study was conducted on the premises of the South Africa Therapeutic Riding Association (SATRA) in Pretoria, South Africa. Parent indemnity forms were signed for both the experimental and control groups prior to the onset of the study, which included all the relevant information the parents required (see appendices A & B). The children themselves also gave their verbal consent after the background to the study was discussed with them.

The subjects were non-randomly assigned to a control group of 4 children (who neither received equi-therapy nor did any other form of horse riding at all), and an experimental group of 4 children (who received equi-therapy over a 3-month period for 1 hour a week). After this 3-month period the control group also received the equi-therapy for a further 3-months, acting as a follow-up control. It is important to note that, as discussed above, the small sample sizes, which are mainly owing to the low prevalence estimates of diagnosed Tourette syndrome patients, comply with the inclusion criteria previously mentioned.

Allowing the control group to participate in the therapeutic horse riding too, entitled the participants in both groups to experience this alternative therapeutic intervention. This also minimised the chance of a control group participant dropping out halfway through the study (Basile, 1997; Von Arbin, 1994).

Both the experimental and control groups were pre- and post-tested 1 week prior to the onset and 1 week after the completion of the actual physical horse riding, using several neuropsychological tests to measure executive function

features. The control group was evaluated again on these tests as a follow up after the completion of their 3-month physical therapeutic horse riding. Each child was evaluated individually by a psychometrist in a private office with no distractions. To minimise the possibility of a changing environment and to keep the test environment constant, tests were administered and instructed in a specific sequence every time. Administration took between 45 and 60 minutes depending on the individual.

In addition to the neuropsychological test battery, certain behavioural aspects were qualitatively evaluated through the use of the Lahey Child Behaviour Checklist (CBCL). This was completed by the parents before and after the intervention.

This specific checklist was also used in the previously discussed study by Basile (1997) on the effect of therapeutic horse riding on attention deficit hyperactive disorder children. Basile found that continued communication with the parents was very important to ensure optimal use of this checklist. In his study the parents were not well informed on what the study was addressing, which led them to complete the checklists haphazardly. A lack of interest resulted in post-tests not being completed by the parents who had originally completed the pre-tests, which had a negative impact on the quality of the checklists. Communicating with the parents was thus an important part of this study's research process, 1 week before and 1 week after the study was completed, as well as after the 10th week of riding for both groups.

The tests used in the required pre- and post-test evaluation for the horse riding therapy on its own are described briefly in the final discussion of the results in chapter 6 because, although not the main focus of this study, this data could have significant additional value. Therefore, the procedures with regard to equi-therapy as intervention are noted as follows:

Individuals are evaluated on a neurophysiological level with regard to their level of sensory integration of the vestibular system and the somato-sensory

system, perception functions of the limbic system and hemispheric integration of the higher cognitive functions. A qualified occupational therapist administers the following tests: Clinical Observations of Dr A.J. Ayres, Southern California Sensory Integration Test (SCSIT), Test of Visual-Perceptual Skills of Dr H. Gardner (TVPS), Developmental Test for Visual Perception of Dr H. Gardner (TVPS-2), Beery Test -- Developmental Test of Visuo-Motor Integration (VMI), Brain Profile Test Derived from Kinesiology.

Following the evaluation, a special programme is worked out by the occupational therapist and a qualified equi-therapist, where certain goals are set to be achieved on the horse to suit the individuals needs. Often inputs regarding the individual from psychologists, physiotherapists, paediatricians, teachers, parents and so on are also incorporated in this programme. Thus, it is very important that not just any activities or exercises are administered. The final aim is to achieve these set goals, and to help the individual as far as possible to be able to ride the horse on his or her own. This only follows after a process of first learning to ride at a walk with helpers, walk without helpers, then to trot, first a sitting-trot and then a rising-trot. The latter is often achieved with the help of special aids or equipment. When the individual has improved so much as not to need to do any activities or receive therapy on the horse anymore, he or she could then be referred for professional riding lessons.

4.3 Data analysis

Both group mean and individual change analyses were implemented. The group mean analysis is appropriate for this specific study as it does not make any assumptions about the form of the distribution of differences, nor does it assume that all participants derive from the same population. The individual change analysis, on the other hand, necessitates the use of a cut-off criterion to determine the amount of change that is commensurate with deficit classification. As there are no definite criteria reflecting the degree of change that warrants a classification of deterioration, the choice of cut-off criterion is

relatively arbitrary and draws from epidemiological studies that use the standard deviation method (Eysenck, Arnold & Meili, 1972).

Since the group (sample) sizes were small, non-parametric statistical tests were used to analyse the data, to test for a significant difference between the scores obtained on the neuropsychological tests before and after the therapeutic horse riding intervention for both the control and experimental groups. Tests that were used are the Mann-Whitney and Wilcoxon rank sum tests (Rosnow & Rosenthal, 1996). The Mann-Whitney compared the post-score baselines of the experimental group, which had received the intervention, and the control group, which had not. The Wilcoxon compared the pre-score and post-score baselines of the experimental and control group after they had both received the intervention.

To supplement the results, additional data was analysed qualitatively. This was obtained from the copy condition of the Rey Osterrieth Complex Figure test, which analysed possible frontal lobe dysfunction, the Lahey Child Behaviour Checklists completed by the parents evaluating certain behavioural aspects, and the pre- and post-tests administered by the occupational therapist for the equi-therapy on its own. Details of the copy condition and the written responses of the parents are explained in more detail in the section on instruments.

Furthermore, to make the results more visually assessable, owing to the small sample size, graphs of the test scores were also used to investigate general trends in the data. Scores achieved for each individual were plotted over the 3-month research periods for both the experimental and control groups before and after they had received the therapeutic horse riding intervention.

4.4 Instruments

A battery of neuropsychological tests was administered, as these tend to assess the modalities related to the executive functions of the brain (Lezak,

1995). These included: attention and concentration, drive and motivation, cognitive/mental flexibility, planning and organisational skills, ability to recognise and correct mistakes, ability to respond to feedback cues, and the ability to understand the consequences of behaviour (Mapou & Spector, 1995; Spreen & Strauss, 1998).

Tests were selected from various studies that were found to have been sensitive instruments for executive function evaluation, to which reference is made in the paragraphs below. The selected tests were

- (i) The Wisconsin Card Sorting Test
- (ii) The Stroop Colour Word Test
- (iii) The Rey-Osterrieth Complex Figure Test
- (iv) The Trail Making Test
- (v) Raven's Progressive Matrices
- (vi) The Digit Symbol Modalities Test (Reversed Form)

With regard to the selection of these tests, it was important to take into consideration that one may tend to choose executive function tests for their face validity rather than their psychometric properties, and that some tests that supposedly measure executive functions lack adequate normative data (Mapou & Spector 1995).

The Lahey (1979) Child Behaviour Checklist was also given to the parents to evaluate certain observable behavioural aspects of their children before and after they received the horse riding therapy.

Individual discussions of each neuropsychological test administered as well as the checklist used follows below.

4.4.1 Wisconsin Card Sorting Test

This popular test of frontal lobe function has been extensively used and validated (Lezak, 1995). It assesses the ability to form abstract concepts, to shift and maintain set, and to utilise feedback, thus providing information on several aspects of problem-solving behaviour beyond such basic indices as task success or failure (Heaton, Chelune, Talley, Kay & Curtiss, 1993; Spreen & Strauss, 1998).

The Heaton *et al.* (1993) version was used in this study. The subject is given a set of 128 stimulus cards, which show objects that differ in three ways: colour, shape and number. Four of the cards are key cards representing these criteria. The subject is instructed to place each new card under one of these four cards, and the examiner will inform him or her whether the choice is 'right' or 'wrong'. The subject is told to use this information to try to get as many cards right as possible. The examiner arbitrarily chooses to have the initial 'right' response to be whatever criteria the subject uses first, such as colour. After ten more consecutive correct sorts, the examiner changes to another criteria, such as shape, without telling the subject. After 10 more consecutive correct responses, the criteria is switched to number. The process continues until six sorting categories are complete or the cards are used up. (All correct matches and errors as well as the type of error made are recorded throughout the test by the administrator.)

With regard to the test-retest reliability, caution was taken with the interpretation, because retesting of subjects often yields different results. This was suggested by Heaton *et al.* (1993) after a study where 46 healthy children and adolescents were given the Wisconsin on two occasions about one month apart. Generalisability coefficients (how well the instrument measures the subjects' true scores) reported by the investigators were only moderate in value, ranging from .37 (percent perseverative errors) to .72 (non-perseverative errors). A perseverative error is when one makes the same error repeatedly, and does not appear to learn from past mistakes. The fact that the standard errors of measurement for children on the Wisconsin are quite large (10.28 for perseverative responses) is proof that caution should be

taken when retesting of subjects is involved. The main reason being that because this instrument's success depends on the sort and shift principle. Once this has been achieved most subjects are unlikely to fail again or use up all the cards while figuring out the solution -- it no longer measures the problem-solving abilities of the subject (Lezak, 1995).

Furthermore, according to Drewe (1974), frontal lobe patients generally commit a large number of errors on this test, especially those of the perseverative type. However, with regard to this study Boucugnani and Jones (1989), Denckla (1996) and Gorestein *et al.* (1989) have also confirmed that this is quite common in Tourette syndrome patients and their related behavioural disorders.

In general, poor performance on categories completed, perseverative errors and failure to maintain set would be indicative of frontal lobe dysfunction (Drewe, 1974; Heaton *et al.*, 1993). These were the scores used in this study.

4.4.2 Stroop Colour Word Test

This test is often used to measure specific higher cognitive functions, mainly assessing the ease with which a person can shift his or her perceptual set to conform to changing demands, and suppress a habitual response in favour of an unusual one, often referred to as selective attention and cognitive flexibility (Aloia, Weed & Marx, 1997; Lezak, 1995; Spreen & Strauss, 1998).

Since it was originally developed by Stroop in 1935, various versions of the test have come into existence. The Victoria version was used in this study. This version was selected mainly because of its short administration time (only 24 items are used) and its sensitivity to frontal lobe dysfunction. The test consists of three cards, each containing six rows of four items. There are three parts to the test: Part D, Part W and Part C. In part D the subject must name, as quickly as possible, the colour of 24 dots printed in blue, green, red,

or yellow. Each colour is used six times, and the colours are arranged in a pseudo-random order on the card, each colour appearing once in each row. Part W is similar to part D, except that the dots are replaced by common words, for example, 'when', 'hard' and 'under', printed in lower-case letters. The subject must name the colours in which the words are printed, and disregard their verbal content. Part C is similar to parts D and W, except that here the coloured stimuli are colour names, for example blue, green, yellow and red printed in lower-case, but so that the print colour never corresponds to the colour name. The three cards are always presented in the same sequence: D, W and C. The subject must call out the colour name as quickly as possible. With regard to this study, time in seconds and uncorrected errors were measured. Specific attention was given to possible poor performance on parts D and W, as well as increased errors on part C, as this could be indicative of frontal lobe dysfunction (Spreen & Strauss, 1998).

Furthermore, Lezak (1995) noted that when a subject has trouble in giving the actual colour when the word printed represents another colour, as in part C, and thus reducing reading speed, it may indicate the inability to give attention and to ignore unusual stimuli. Shum and his colleagues (in Lezak, 1995) also described the task at hand in part C as the selective processing of one visual aspect whilst other aspects are constantly blocked out. The habit of reading the word no matter what colour it may be printed in has to be countered, and a more selective process of attention must be applied so that the actual colour of the word may be verbalised.

Although selective attention seems to be the main area of measurement in this test, behavioural and motor adaptation is also seen, which may also be related to frontal lobe dysfunction (Mirsky, Anthony, Duncan, Ahrearn & Kellam, 1991). It is interesting to note that this test is frequently used with patients in their first stages of Parkinson's disease, known as dysexecutive syndrome, which is mainly caused by lowered levels of dopamine in the frontal areas of the brain affecting development of functions that include attention, emotional behaviour, complex psychomotor performance and,

moreover, disrupting working memory (Martin, 1998; Rothenberger, 1990). This is mainly why this test may also be sensitive to Tourette syndrome patients, as the cause of this syndrome is often related to an abnormal metabolism of dopamine and serotonin levels in the medial-prefrontal areas of the brain, affecting the same developmental functions (Comings, 1990; Lakke & Wilmink, 1985; Rothenberger, 1990). However, in Tourette syndrome the dopamine levels are higher, causing a higher frequency of abnormal movements (tics), whereas in Parkinson's it is the opposite. Research by Gorenstein *et al.* (1989) has shown various deficits in the theoretical aspects of this test in children with a hyperactive nature, which may be related to Tourette syndrome, confirming the latter.

The test-retest reliability of the Stroop test is satisfactory with reliability coefficients of .90, .83, and .91 for the three parts of the test after one-month intervals between the tests. However, practice-effect does affect performance, improving on about 2 seconds on parts D and W, and by about 5 seconds on part C. These increases may not affect result interpretation if the interpretation is based on pattern and not level, because all scores increase consistently (Lezak, 1995).

4.4.3 Rey-Osterrieth Complex Figure Test

This is one of the most extensively used neuropsychological tests. This test basically assesses visuospatial constructional ability and visual memory. It is also very helpful in assessing organisational strategies. These include other cognitive processes such as planning and problem-solving strategies, as well as perceptual, motor, and memory functions (Lezak, 1995; Mapou & Spector, 1995; Spreen & Struass, 1998).

The Rey-Osterrieth Complex Figure Test is a paper and pencil test, which consists of two blank pieces of paper and a Rey-Osterrieth figure. The basic procedure involves having the subject copy a figure and then, without prior warning, asking them to reproduce or recall it from memory. Immediate recall

and delayed recall measures may be used, however, times and number of delays may vary from administration to administration, from 3 minutes to 45 minutes (the length of delay chosen does not affect overall performance, provided the delay is not longer than 1 hour) (Lezak, 1995). For the purpose of this study a 30-minute delayed recall was used between the subject's copy and the recall of the drawing. No immediate recall was used (Bennett-Levy, 1984). During administration of the test, the subject's logical construction of the figure was observed, as well as omissions and mutations. This was achieved through reproduction of the subject's drawing on a separate sheet, noting the order (by numbering) and the directionality of each line as it was drawn.

Following Lezak's (1995) well-established scoring method for this test, a score based on a total of 36 was generated for both the copy and the delayed recall sections of the test. The copy condition of this test was also analysed qualitatively, to establish if a possible frontal lobe dysfunction was indicated. The latter was achieved in conjunction with the administrator's reproduction of the subject's drawing, a random order in which components of the figure were drawn (lack of planning and organisation), inclusion of components not in the original figure (disinhibition), or retracing of components once drawn (motor perseveration) (Walsh, 1987). A drawing displaying any or all of the above characteristics was classified as 'frontal'. A 'normal' performance was any copy that showed none of the above characteristics or any other errors to a greater extent. The copy score, the delayed recall score and the qualitative categorising of the drawing were measured in this study. Thus, impairment on the delayed recall score and a qualitative 'frontal' performance on the copy section were presumably associated with frontal lobe dysfunction.

Throughout the administration it was, however, kept in mind that the subjects may experience considerable motor difficulty due to their motor tics, which could have affected their drawing, possibly also affecting concentration and overall performance. Fortunately none of the subjects were affected by severe motor tics: they all completed the drawing within the 5-minute

standard drawing time as required in Lezak (1995), thus the tests were administered and interpreted according to the required procedure.

The test-retest reliability of the Rey Complex Figure is quite high, from the interscorer reliability between various scoring methods to the repeated administration of the test. Spreen and Strauss (1998) found that with repeated administration of the same figure, practice effects began to occur. In general, normal subjects showed a normal 10% improvement in percent recall scores when retested after a one-month interval. Furthermore, an evaluation administered by Meyers and Meyers (1995) with 12 normal subjects over a 6-month interval also proved the percentage agreement between the first and second testing session to be high (91.7). They also reported no significant differences for other Complex Figure Test variables across the retest interval. However, another study administered over a 1-year interval found that the copy condition was not reliable across this interval. Reliabilities for the immediate and 30-minute-delay recall trials were in the moderate range (.47-.59). This may be due to the restriction of the maximum- or near-maximum-level performance attained by most normal subjects, thus artificially reducing the size of the test-retest correlation coefficients. For the purpose of this study, however, an interval of 3 months was applied, thus test-retest reliability should not be affected other than the expected percentage improvement that is generally found.

Walsh (1987) found that in frontal lobe patients, when completing the Rey Complex Figure test, their reproductions fail to integrate the elements as parts of a whole. This may be mainly because of their inability to form a stable plan to produce the drawing, although their spatial relationships between elements of the figure are normally found to be well preserved. Furthermore, frontal lobe patients also tend to do far worse on the recall section of the test, seemingly due to a frontal memory deficit, and not a primary memory deficit.

Interestingly, the area of visuospatial constructional ability as measured in the Rey test, can be seen as closely interrelated to visuomotor integration ability,

which is one of the areas known to be problematic for Tourette syndrome patients. Thus, a poor performance in this regard was predicted for this study. In another related study by Denckla (1996), based on the application of certain clinical measures of executive function, this test was administered to Tourette syndrome and related attention deficit hyperactivity disorder children with little or no deficits found with regard to their perceptual organisational scores, whereas other researchers such as Boucugnani and Jones (1989), and Grodzinsky and Diamond (1992) reported significant deficits for one or other of these measures.

4.4.4 Trail Making Test A and B

The Trail Making Test, which is a subtest of the Halstead-Reiten Test Battery, is widely used in neuropsychological practice as part of a battery for detecting neuropsychological dysfunction. It has been reported to be a highly sensitive instrument in differentiating brain-damaged from non-brain-damaged patients (Reitan, 1955, 1958; Spreen & Strauss, 1998). The test is a short test of selective attention and cognitive shift abilities, primarily designed to measure adequacy of cerebral functioning, presumably frontal lobe functions, and particularly, visual scanning and conceptual tracking (Abraham, Axelrod & Ricker, 1996; Lezak, 1995; Spreen & Strauss, 1998).

The revised version of the Trail Making Test developed by Reitan (1955) was used. This is a paper and pencil test made up of two parts: part A and part B. In part A the subject is required to join numbered circles ranging from 1 to 8 for the practice sample, and from 1 to 15 for the actual test, as quickly as possible while being timed. Part B is similar to part A, except that the circles in this case contain either numbers or letters. The numbered circles range from 1 to 4, and the lettered circles from A to D for the practice sample, and from 1 to 8 and A to G for the actual test. As in part A, the subject is required to join the circles in ascending number-letter sequence as quickly as possible while being timed (1 to A, A to 2, 2 to B, and so on). Both time scores in seconds, and errors on each form were recorded. Lezak (1995) found the

second administration procedure more reliable than when only time scores are used, since error correction may take a variable amount of time, depending on the comprehension of both the subject and the administrators. Thus, she recommended the use of a difference score (B minus A) to eliminate possible variability -- a procedure that was used in this study.

As mentioned above, the test is a well-established indicator of brain damage (Reitan, 1958), but more recently part B has been characterised as an indicator of frontal lobe function (Walsh, 1987). The frontal lobe patient tends to perform part B more slowly and make more errors than on part A (Walsh, 1987). This reflects the frontal patient's inability to shift set in an ongoing activity, in this case from the strategy of numerical sequencing to that of alphabetical sequencing (Spreeen & Strauss, 1998). The latter received specific attention during analysis of the time and error variables for part B. It is, however, important to note that slow performance for one or both parts may indicate frontal lobe or brain damage, but in themselves do not indicate whether the problem is motor-slowness, poor co-ordination, visual-scanning difficulties, poor motivation, or conceptual confusion (Lezak, 1995). Walsh (1987) further notes that apart from its general use as a speeded visuomotor tracking task, patients with frontal lobe lesions, particularly those with basomedial damage, have difficulty with the flexible control of inhibition needed for the task.

The reliability of the test varies from one administration situation to another, but in general it is higher than 0.60. Coefficients of 0.80 and higher are normally indicated (Lezak, 1995). Interscorer reliability has been reported as .94 for part A and .90 for part B. Studies conducted over 6-month intervals have claimed significant improvements and practice effects with a reliability of .98 for part A and .67 for part B. Even a study conducted with a 1-year interval showed a high score for retest reliability of .94 for part A and .72 for part B (Lezak, 1995; Spreeen & Strauss, 1998). Thus, with regard to this study, reliability for the use of the test is expected to be high as the retests were administered over 3-month periods.

Chapman (1994) has successfully administered this test to Tourette syndrome children, finding significantly lower scores on part B of the test. This could possibly be related to the previously mentioned poor performance on visuomotor integration abilities for Tourette syndrome children in general, leaving the impression that the participants could perform poorly on part B of this test.

4.4.5 Raven's Standard Progressive Matrices

The Raven's Standard Progressive Matrices was developed as a measure of non-verbal analogical reasoning. Raven's is a useful test to administer to subjects' with expressive language problems, since it does not necessarily require verbal responses (Raven, 1960). This was important to this study because Tourette syndrome patients with severe vocal tics would be able to complete this test with ease. Low scores on this test could be indicative of possible frontal lobe (executive) dysfunction in the subjects (Mapou & Spector, 1995).

The original Raven (1960) method was administered in this study. Often used to evaluate intellectual efficiency (learning from immediate experience with problems) and conceptual abilities, the test has no time limit and consists of 60 problems grouped into 5 sets (A to E). The subject views a pattern problem with one part removed, and must choose the pattern that best completes the sequence from a set of 6 to 8 alternatives. The problems become increasingly difficult within each set of 12 patterns. Because of the increasing difficulty in the problems, only 3 sets, A to C were administered. This is often done when younger children are tested, as was the case in this study (Spren & Strauss, 1998). Correct responses were scored.

Test-retest reliability correlations run in the range of .7 to .9, even when retesting involves three administrations 6 and 12 months apart. Moreover, the use of this test has proved to be very stable, with no significant shift in mean

scores between three administrations (Lezak, 1995). Its validity as a measure of general ability has been constantly supported in correlational studies with other ability measures in which, for the most part, children have been the subjects (Llebre, 1984). Thus, for this study, test-retest reliability should be found to be of a stable nature.

4.4.6 Symbol Digit Modalities Test

Originally developed as a measure for screening for cerebral dysfunction in children and adults, the test is administered currently to assess visual-associative learning ability, psychomotor/response speed, visuomotor integration and co-ordination. Short-term memory for non-verbal information and processing of non-verbal stimuli, which are functions of the right brain, are also assessed (Chapman, 1994). However, with regard to the latter it is important to note that this test tends to be affected regardless of the location of a lesion, and thus is of little use for predicting the laterality of a lesion. The test has shown impairment with lesion in virtually any location in a high proportion of cases (Lezak, 1995). This test is based on the assumption that the associative learning ability, which is required to learn and is the relation between specific symbols and digits, is an indication of general intelligence (Spreeen & Strauss, 1998).

The test is similar to the Digit Symbol Substitution Test, a subtest of the Wechsler Adult Intelligence Scale (WAIS) or the Coding subtest from the Senior South African Adult Intelligence Scale Revised (SSAIS-R), requiring substitution under time constraints. However, this format developed by Aaron Smith (1991) is slightly altered in that the subject is required to examine a series of 9 meaningless geometric designs, and for each symbol in the sequence, search a key for that symbol and substitute a number, either orally or in writing, for the symbols. Ninety seconds are allowed to complete the trail. The test may be administered written (the patient places the numbers in the boxes below the marks according to the key provided at the top of the page), orally (the administrator records the numbers spoken by the patient) or

in both forms. If both forms of the test are administered, as was the case in this study, the recommended procedure is to administer the written version first. A practice trial of 10 boxes is allowed, which do not form part of the final score. The scoring of the test consists of the number of correct substitutions in each 90-second interval (Spreen & Strauss, 1998).

The test-retest reliability of this test is good, with coefficients of .82 and higher. No learning by practice was noted when the test was administered 4 times with intervals varying between 1 week to 3 months (Lezak, 1995).

To conclude, the assumption could be made that deficits in visuomotor integration and co-ordination abilities for the Tourette syndrome subjects may be predicted for this test, as this is a known problem area for them, as previously discussed.

4.4.7 Lahey Child Behaviour Checklist

This checklist analyses empirically generated descriptions of maladaptive behaviours, such as diagnostic descriptions used in child guidance clinics. Each item in the list consists of a description of an aspect of maladaptive behaviour, with a full set of items, being representative of the entire range of maladaptive child behaviours. The list includes items related to hyperactivity, conduct problems, learning disabilities and attention. However, for the purpose of this study, parents were also asked to comment on additional points with regard to their children's Tourette syndrome features.

The lists were given to the participants' parents to complete before and after the physical horse riding therapy took place. The main reasons for the use of the checklist was firstly because of the interrelatedness of the behaviours to Tourette syndrome. Secondly, the checklist was used successfully in a previous study by Bruun and Bruun (1994) on Tourette syndrome and its related disorders concerning the observation of behavioural changes. Thirdly, and most importantly, the use of this checklist together with the other

neuropsychological tests measuring executive frontal lobe (executive) functioning is valuable in the sense that it enables one to observe the participant's level of function in his or her natural environment, whereas the structured test situation provided by conventional neuropsychological testing may actually mask the expression of deficits in this area. This is even more concerning when the executive functions are evaluated, because the main focus is on 'self-structure' as previously described in the definition of executive function. However, with regard to this study, the written responses of the parents were qualitatively screened for positive and negative changes in various behavioural features.

4.5 Conclusion

Participants were referred by various neurologists and paediatricians after they had been diagnosed according to the DSM-IV criteria for Tourette syndrome. They were divided non-randomly into an experimental and control group. The experimental group received therapeutic horse riding for 3 months, whilst the control group did not. Then, for the following 3 months the control group also received horse riding therapy. Each participant was evaluated individually on 6 neuropsychological tests. These results were statistically analysed through the use of a group mean and an individual change analysis. Additional data from the copy condition of the Rey-Osterrieth Complex Figure test, Lahey Child Behaviour Checklists completed by the parents and tests administered by the occupational therapist for the horse riding therapy on its own were analysed qualitatively. The analysed data was used to confirm the hypothesis that therapeutic horse riding (equi-therapy) could have a positive influence on the executive functioning of Tourette syndrome children. The results are discussed in chapter 5.

CHAPTER 5

RESULTS

5.1 Introduction

In this chapter the results of the data analyses of the test scores obtained are discussed.

The test score results that were collected through the use of the 6 different neuropsychological tests were divided into 2 sets of scores. These scores are related to the hypothesis mentioned in chapter 1:

The therapeutic horse riding will have a positive influence on the executive functions of the Tourette syndrome participants.

The first set of scores consisted of the scores of the experimental group, which had received the therapeutic horse riding intervention, and the control group, which had not. The second set of scores was for the experimental and control group after they had both received the therapeutic horse riding intervention.

Thus, a data analysis for each individual test was performed to assist in estimating if mean scores achieved for each test could be differentiated. Following this a discriminant analyses of all test scores obtained were compared with the use of non-parametric tests to determine whether significant differences existed. Graphs were also used to make possible individual changes more visually assessable.

Furthermore, the results obtained from the copy condition of the Rey Osterrieth Complex Figure test, the Lahey Child Behaviour Checklists and

the pre- and post-tests administered by the occupational therapist for the horse riding therapy on its own were analysed qualitatively, which was of significant additional value, specifically because of the small sample sizes that were used in the study.

5.2 Results of the individual tests

Using the non-parametric Mann-Whitney rank sum test to compare the results of the experimental group, which had received the therapeutic horse riding intervention, and the control group, which had not, the results indicated 3 significant differences. These were on the Wisconsin Card Sorting Test for categories completed and failure to maintain set, and on the Stroop Colour Word Test for uncorrected errors on part C of the test. However, owing to the small sample size, a significant difference between the experimental and control group was not expected.

A group mean analysis of the scores obtained by the non-parametric Wilcoxon rank sum test was used to compare the experimental and control group after they had both received the therapeutic horse riding intervention. The results indicated 4 significant differences for time in seconds on part W as well as for uncorrected errors on part W and part C of the Stroop Colour Word Test, and for correct written substitutions on the Symbol Digit Modalities Test.

Furthermore, an individual change analysis was obtained through the use of graphs for both the experimental group with and the control group without, as well as for all the participants after they had received the therapeutic horse riding intervention. The graphs indicated various individual changes throughout the study.

In the following sections the results of the group mean analysis and the individual change analysis are discussed.

5.2.1 Wisconsin Card Sorting Test

The scores that were used are categories completed, perseverative errors and failure to maintain set.

Means and standard deviations measured for the first set of scores are given in table 5.1.

Table 5.1 Scores obtained on the Wisconsin Card Sorting Test for the experimental group with and the control group without the therapeutic horse riding intervention.

Category	Ex group with THR Mean (SD) N=4	Cont group without THR Mean (SD) N=4	P-Value
Categories Completed	-1.75 (1.2583)	-0.25 (0.5000)	0.0885*
Perseverative Errors	3.2500 (19.3972)	5.0000 (5.8878)	0.7728
Failure To Maintain Set	-0.7500 (0.9574)	0.2500 (0.5000)	0.0982*

*Significant, $p < 0.1$

No significant difference for any of the indices was measured, although at a 10% level of significance ($p < 0.1$) scores obtained were significant for categories completed ($p = 0.0885$) and failure to maintain set ($p = 0.09828$). All the participants of both groups obtained either the same score or improved their scores on these indices, except for participants 3 and 4 of the experimental group who obtained slightly higher scores.

On analysing the various means, a difference was found between the categories measured, although not enough to indicate a significant difference. The experimental group that received the therapeutic horse riding intervention achieved higher averages for all three categories, especially for categories completed and perseverative errors. The latter results were in the expected direction because they had received the therapeutic horse riding intervention.

Furthermore, when the individual test scores were analysed with graphs for each participant of the experimental group with and the control group without the intervention, it was noted that all the participants from the experimental group obtained higher or the same scores on categories completed, participant 2 made more perseverative errors on the post-test, whereas participants 3 and 4 obtained slightly higher scores on the failure to maintain set indice. The individual scores for the control group remained more or less the same from the pre- to the post-test for categories completed. Less perseverative errors were made on the post-test, except for participant 4 who made slightly more errors. As for failure to maintain set, all participants except participant 1 obtained the same scores. However, the higher scores for perseverative errors obtained by participant 2 of the experimental group and participant 4 of the control group weren't big enough to show a significant difference. Possible reasons for these scores are discussed in chapter 6. (See figures 5.1 - 5.3 for individual scores obtained).

The second group of scores is for the experimental and control group after they had both received the therapeutic horse riding intervention. Means and standard deviations of the group for each indice measured are given in table 5.2.

Table 5.2 Scores obtained on the Wisconsin Card Sorting Test of the experimental and control group with the therapeutic horse riding intervention.

Category	Ex and Cont with THR Mean (SD) N=8	P-Value
Categories Completed	-0.8750 (1.2464)	0.2500
Perseverative Errors	3.1250 (13.0432)	0.2578
Failure To Maintain Set	-0.6250 (1.0607)	0.2500

No significant differences were measured.

However, when the graphs for each participant were analysed individually after both groups had received the intervention, post-test scores indicated that all 8 participants improved their scores for categories completed. This possibly indicates that both groups could have benefited from the intervention. For perseverative errors made, improvement was achieved by most of the participants, except for participant 2 from the experimental group previously mentioned. Furthermore, post-test scores achieved on failure to maintain set for participants 1 and 4 of the control group, and the previously mentioned participants 3 and 4 of the experimental group indicated poorer performances. All the remaining participants showed the same or slightly improved scores for this indice. However, these score differences were not big enough to show a significant difference. Possible reasons why these scores were obtained are discussed in chapter 6. (See figures 5.1 - 5.3 for individual scores obtained.)

Figure 5.1 WCST Individual scores - Categories completed.

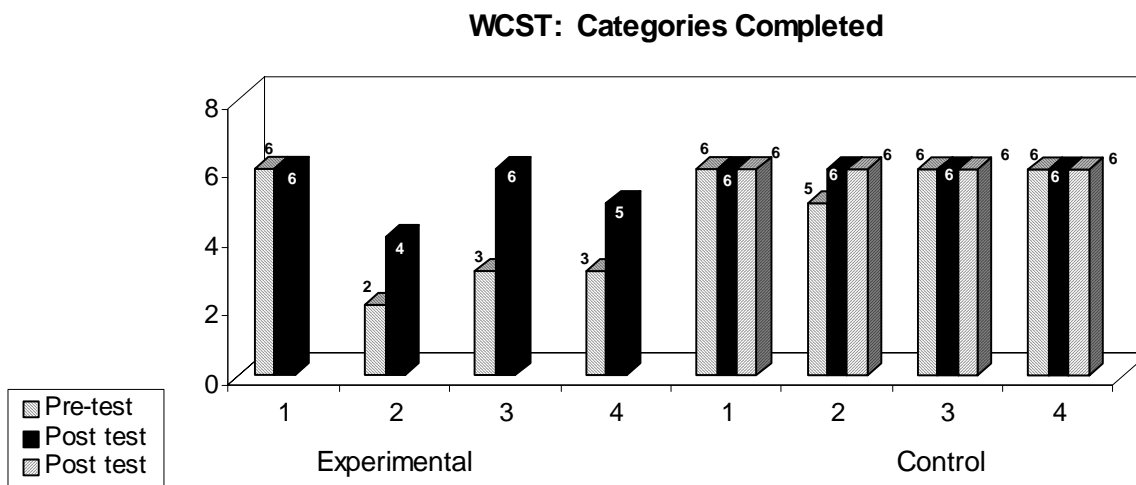


Figure 5.2 WCST Individual scores - Perseverative errors.

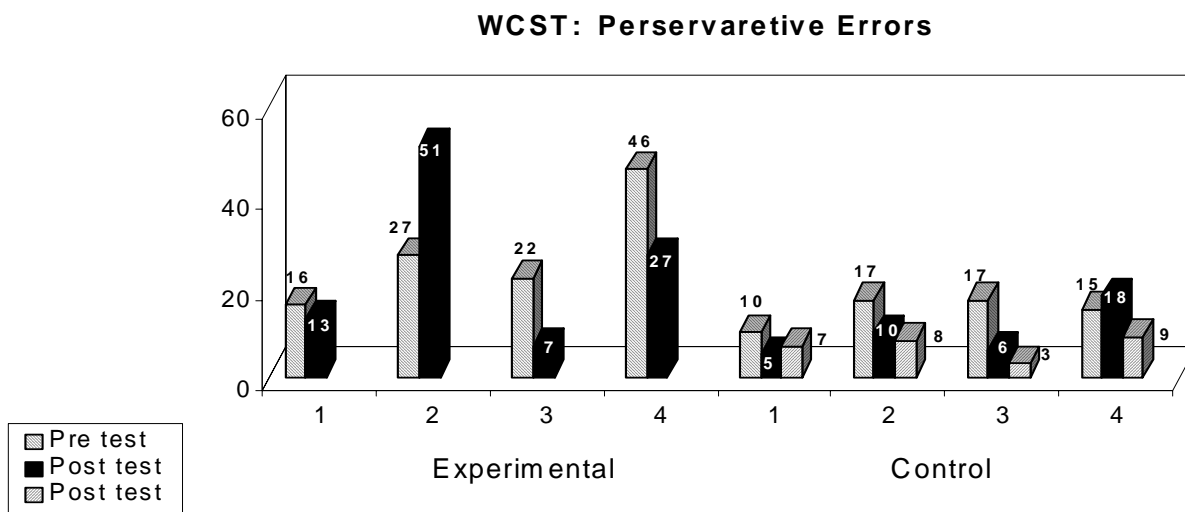
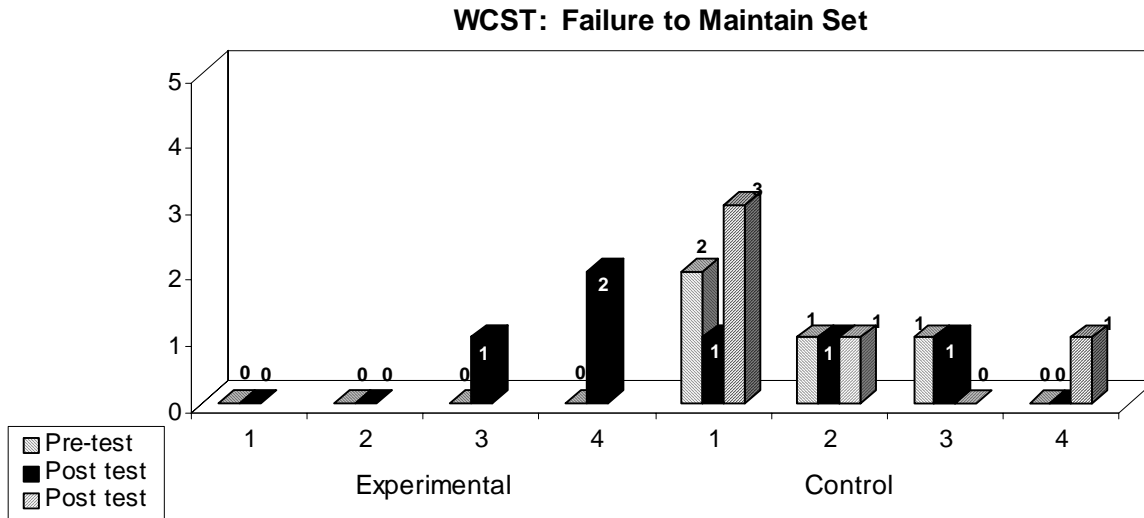


Figure 5.3 WCST Individual scores - Failure to maintain set.



5.2.2 Stroop Colour Word Test

The scores that were used for this test are time in seconds and uncorrected errors.

Means and standard deviations measured for the first set of scores are given in table 5.3.

Table 5.3 Time in seconds and uncorrected errors obtained on the Stroop Colour Word Test for the experimental group with and the control group without the therapeutic horse riding intervention.

Category	Ex group with THR Mean (SD) N=4	Cont group without THR Mean (SD) N=4	P-Value
Time in seconds Part D	1.0000 (6.2716)	2.5000 (5.7446)	0.7715
Part W	6.7500 (6.2383)	2.0000 (24.6171)	0.5637
Part C	1.2500 (4.0311)	0.7500 (7.5000)	0.2367
Uncorrected errors Part D	0.2500 (0.9574)	1.5000 (1.9149)	0.3719
Part W	3.0000 (3.1623)	1.5000 (3.8730)	0.4678
Part C	2.5000 (0.5774)	4.7500 (1.2583)	0.0360 *

*Significant, $p < 0.05$

The only significant difference measured was at a 5% level of significance ($p < 0.05$) on part C of the test for uncorrected errors ($p = 0.0360$). All participants improved on their uncorrected errors from the pre-test to the post-test (see figure 5.9). As part C of this test is often indicative of frontal lobe (executive) dysfunction as discussed previously, possible improvement of self-correction and selective attention was indicated for all participants. Thus for the experimental group these results were in the expected direction. However, the improvement was not necessarily due to the therapeutic horse riding intervention alone as the control group also made fewer errors without receiving the intervention. This could be indicative of a learning / familiarisation ability that was acquired from the pre-test to the post-test for both groups, or possible extraneous variables.

On analysing the various means, a difference was found between the categories measured. The experimental group, which received the therapeutic horse riding intervention, only achieved higher averages for 3 of the categories measured: time in seconds on part D and uncorrected errors on part D and C of the test. For all the other indices, the control group that had not received the intervention obtained higher averages. Thus the differences indicated by the means were not in the expected

direction because the experimental group did not achieve overall higher averages after receiving the intervention.

When the individual test scores were analysed with graphs for each participant of the experimental group with the intervention, and the control group without the intervention, it was found that all the participants of the experimental group showed an improvement or maintained the same scores on all parts of the test, except for participant 3 who took longer to complete part D. Like the experimental group, the control group also improved or had more or less the same time scores on all the parts of the test. However, participant 3 took longer to complete part W and C and participant 2 took longer on all the parts of the test. For uncorrected errors measured, the experimental group once again either maintained or improved their scores on all parts of the test, except for participant 1 who made slightly more uncorrected errors on part D, although this difference was small and of little significant value. The control group also either maintained or improved their scores, except for participant 2 who made more uncorrected errors on part W. These higher time and uncorrected error scores obtained by participant 2 of the control group could suggest a possible frontal lobe dysfunction measured by this test. However, except for uncorrected errors on part C as previously mentioned, these score differences were not big enough to show a significant difference. Possible reasons for the scores obtained are discussed in chapter 6 (See figures 5.4 to 5.9 for individual scores obtained.)

The second group of scores is for the experimental and control group after they had both received the therapeutic horse riding intervention. Means and standard deviations of the group for each indice measured are given in table 5.4.

Table 5.4 Time in seconds and uncorrected errors obtained on the Stroop Colour Word Test for the experimental and control group with the therapeutic horse riding intervention.

Category	Ex and Cont with THR Mean (SD) N=8	P-Value
Time in seconds Part D	0.8750 (5.5918)	0.5547
Part W	7.2500 (7.4785)	0.0469 *
Part C	5.0000 (6.8243)	0.1953
Uncorrected errors Part D	0.2500 (0.7071)	0.6250
Part W	2.5000 (2.5635)	0.0469 *
Part C	1.6250 (1.3025)	0.0313 *

*Significant, $p < 0.05$

Significant differences were measured at a 5% level of significance ($p < 0.05$) on part W for time in seconds and part W and C for uncorrected errors made. Regarding the time in seconds for part W, all participants improved on their scores except for 1 participant who took longer to complete the test after receiving the intervention. This indicates a possible frontal lobe dysfunction, owing to the increase in time to complete this part of the test (see figure 5.5). As for the significant difference measured in the uncorrected error scores on part W and C, all participants improved on their uncorrected errors obtained in the pre-test. This indicates possible improvement of self-correction and selective attention for all the participants, which could be related to the intervention received. Further reasons for these differences measured are discussed in chapter 6. (See figures 5.8 and 5.9.)

Furthermore, when the graphs of each participant were analysed individually after both groups had received the intervention, it was noted

that all the control group participants either maintained or improved their times and made fewer uncorrected errors on all parts of the test. However participant 2 of the control group took a longer time to complete parts W and C. As discussed previously, the participants of the experimental group had either improved or showed more or less the same scores for both time in seconds and uncorrected errors measured, except for participant 3 who took longer to complete part D. These longer times and less uncorrected errors scores for participant 2 of the control group and participant 3 of the experimental group could be indicative of a possible improvement in selective attention measured by this test. Possible reasons why these scores were obtained are discussed in chapter 6. (See figures 5.4 – 5.9 for individual scores obtained.)

Figure 5.4 Stroop Individual scores – Time in seconds Part D.

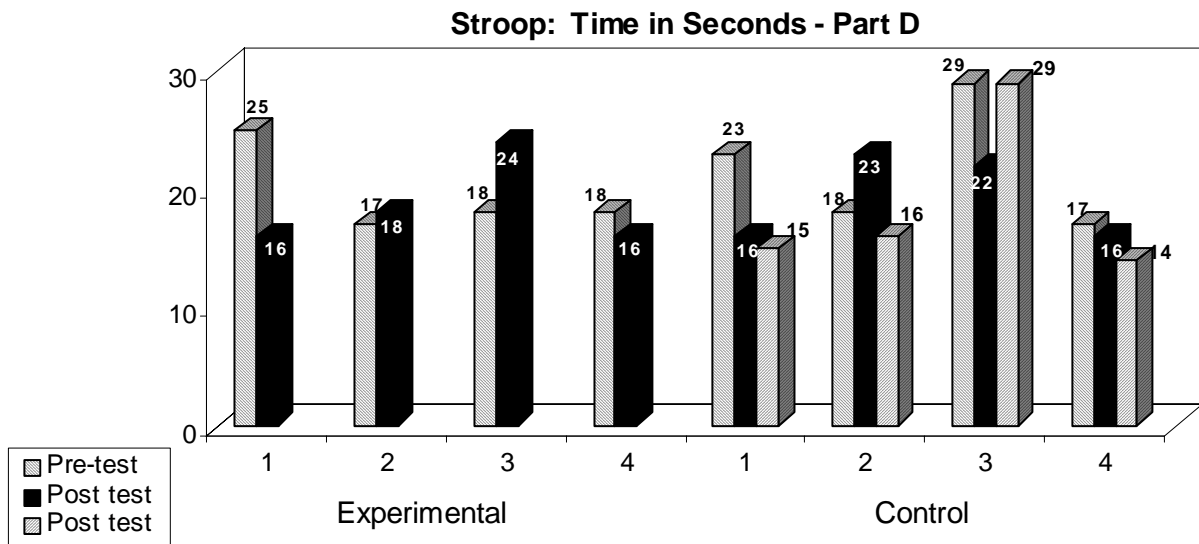


Figure 5.5 Stroop Individual scores – Time in seconds Part W.

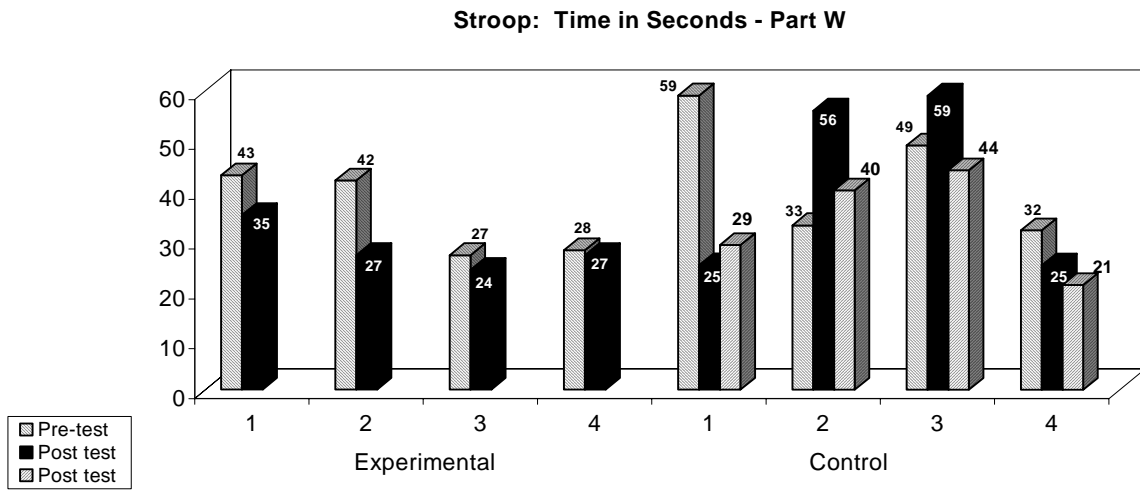


Figure 5.6 Individual scores – Time in seconds Part C.

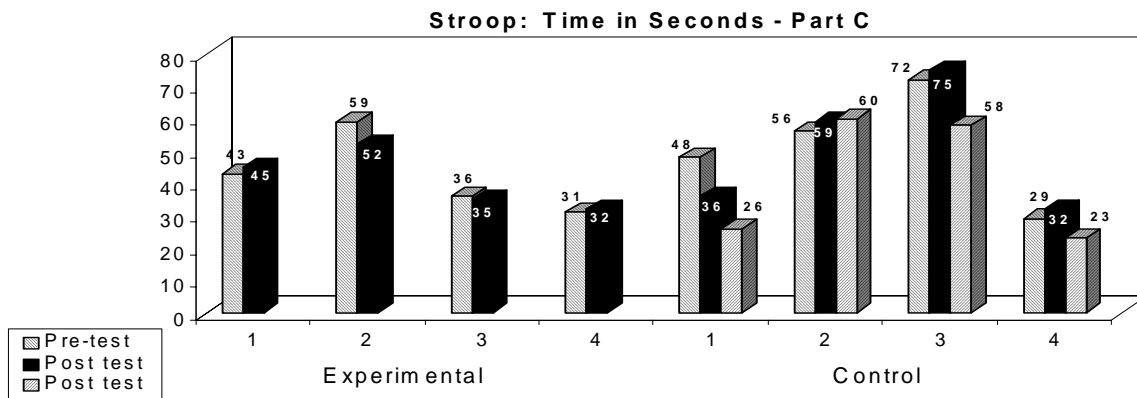


Figure 5.7 Individual scores – Uncorrected errors Part D.

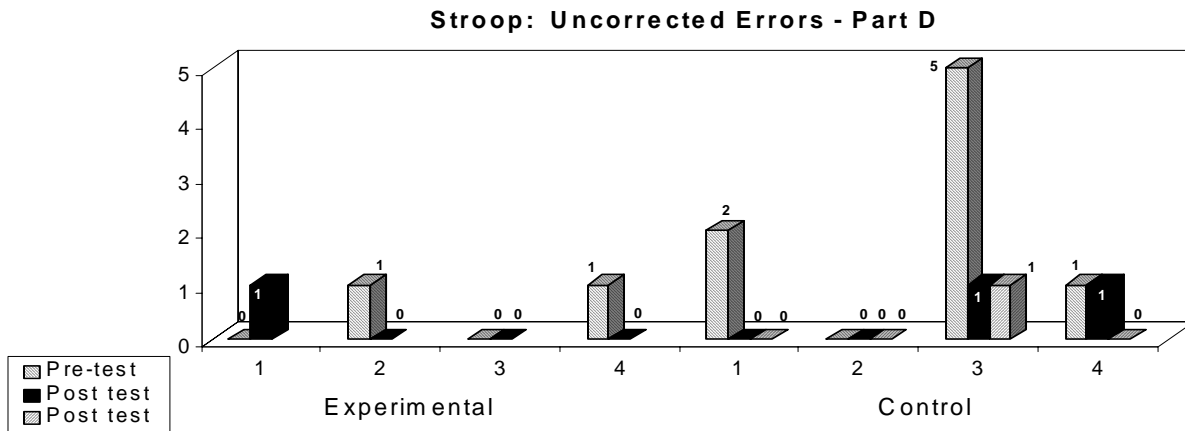


Figure 5.8 Individual scores – Uncorrected errors Part W.

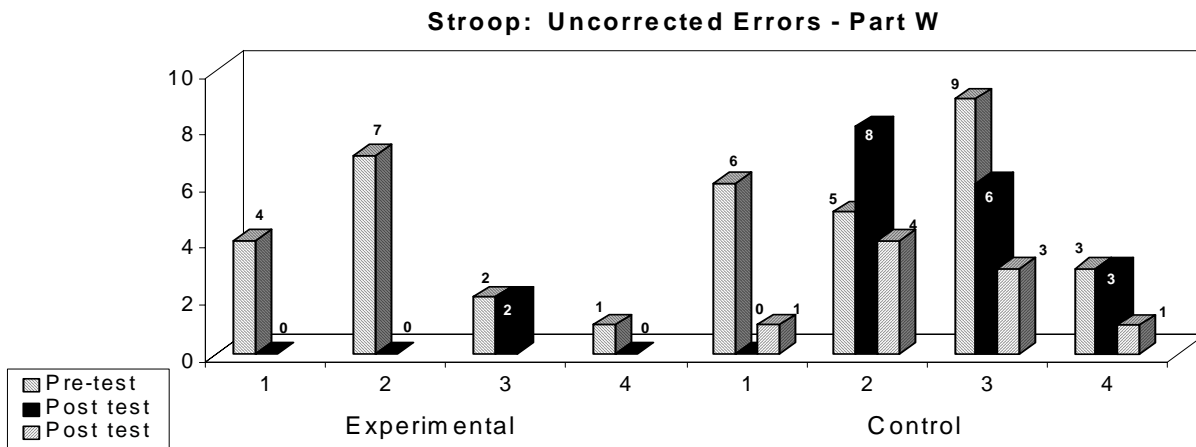
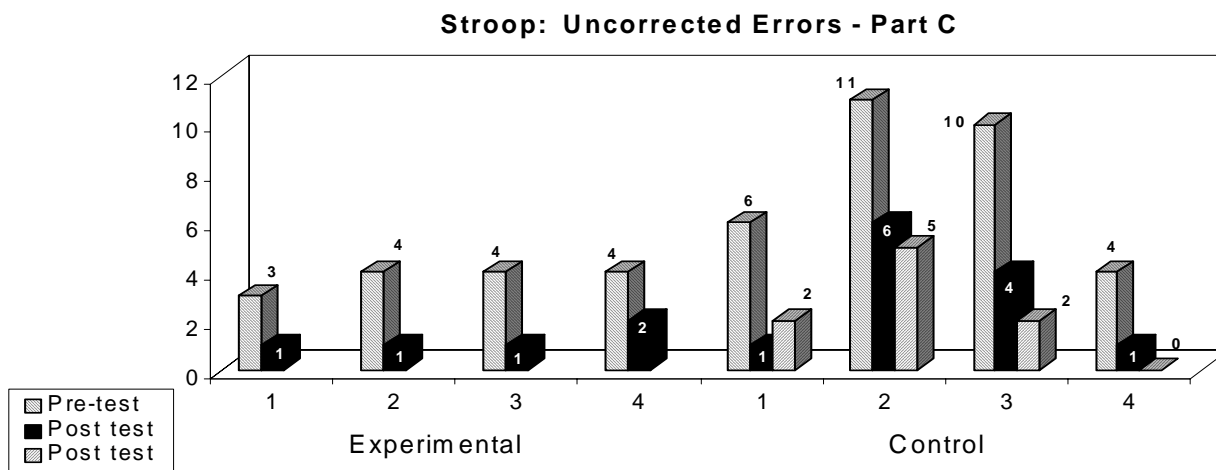


Figure 5.9 Individual scores – Uncorrected errors Part C.



5.2.3 Rey-Osterrieth Complex Figure Test

The scores that were used are the copy and delayed recall scores. A qualitative categorisation of the drawings ('normal' or 'frontal') were also measured for possible frontal lobe dysfunction, which is discussed in more detail in 5.3.

Means and standard deviations measured for the first set of scores are given in table 5.5.

Table 5.5 Copy and delayed recall scores obtained on the Rey-Osterrieth Complex Figure Test for the experimental group with and control group without the therapeutic horse riding intervention.

Category	Ex group with THR Mean (SD) N=4	Cont group without THR Mean (SD) N=4	P-Value
Copy	-0.3750 (4.3851)	-1.3750 (4.9054)	0.8845
Delayed Recall	2.0000 (9.0185)	-2.6250 (7.0163)	0.1913

No significant differences were measured.

By analysing the various means, a difference was found between the indices measured. The experimental group obtained a higher average on their scores than the control group. Thus, the results were in the expected direction because the experimental group had received the therapeutic horse riding intervention. However, these differences were not big enough to measure a significant difference.

When the individual test scores were analysed with graphs for each participant of the experimental group with intervention and the control group without the intervention, the following was noted: participants 1 and 3 of the experimental group and participant 1 and 4 of the control group all obtained lower copy scores from the pre-test to the post-test. Participants 1, 2 and 3 of the experimental group and 2 and 4 of the control group obtained lower delayed recall scores. The rest of the participants all obtained higher scores for both categories, which could be related to the intervention received. However, once again these differences were not

big enough to measure a significant difference. It is interesting to note is that participants 1 and 3 of the experimental group and participant 4 of the control group all had lower scores for both categories measured, which may be indicative of a frontal memory or visuospatial constructional disability, aspects often related to Tourette syndrome as previously discussed. Further possible reasons why these scores were obtained are discussed in chapter 6 (See figures 5.10 and 5.11 for individual scores obtained).

The second group of scores was for the experimental and control group after they had both received the therapeutic horse riding intervention. Means and standard deviations of the group for each indice measured are given in table 5.6.

Table 5.6 Copy and delayed recall scores obtained on the Rey-Osterrieth Complex Figure Test for the experimental group and control group with the therapeutic horse riding intervention.

Category	Ex and Cont with THR Mean (SD) N=8	P-Value
Copy	0.0625 (6.6194)	0.7422
Delayed Recall	1.1875 (7.3238)	0.7422

No significant differences were measured.

When the scores were further analysed, with graphs for each individual participant after both groups had received the intervention, the post-test scores of the control group indicated that participants 1, 3 and 4 showed improvement in their copy and delayed recall scores. However, participant 2 obtained lower scores for both categories, which coincided

with his previous delayed recall post-test score without the intervention. This also could indicate a possible frontal memory or visuospatial constructional disability, as was the case with the 2 participants on the first set of scores. As previously discussed, the experimental group participants 1 and 3 had lower copy scores and participants 1,2 and 3 had lower delayed recall scores. Participants 2 and 4 obtained higher copy scores, whereas participant 4 obtained higher scores in both categories. Thus, only 4 participants showed an improvement after receiving the intervention for both the copy and delayed recall scores. Although, none of the score differences given above were big enough to show a significant difference, possible reasons for these results are discussed in chapter 6. (See figures 5.10 and 5.11 for individual scores obtained.)

Figure 5.10 Rey Individual scores - Copy Scores.

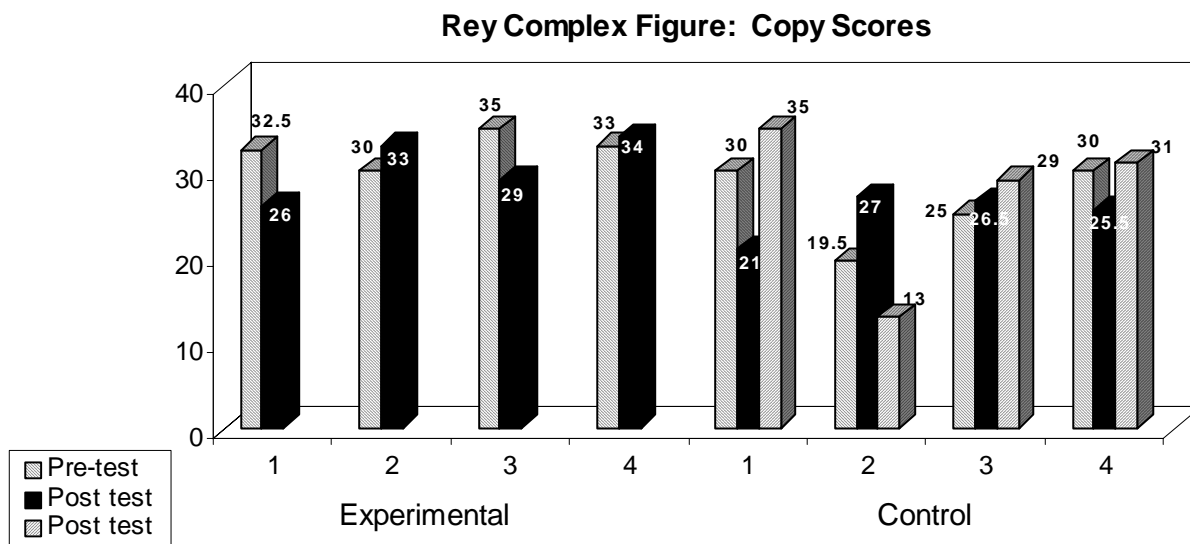
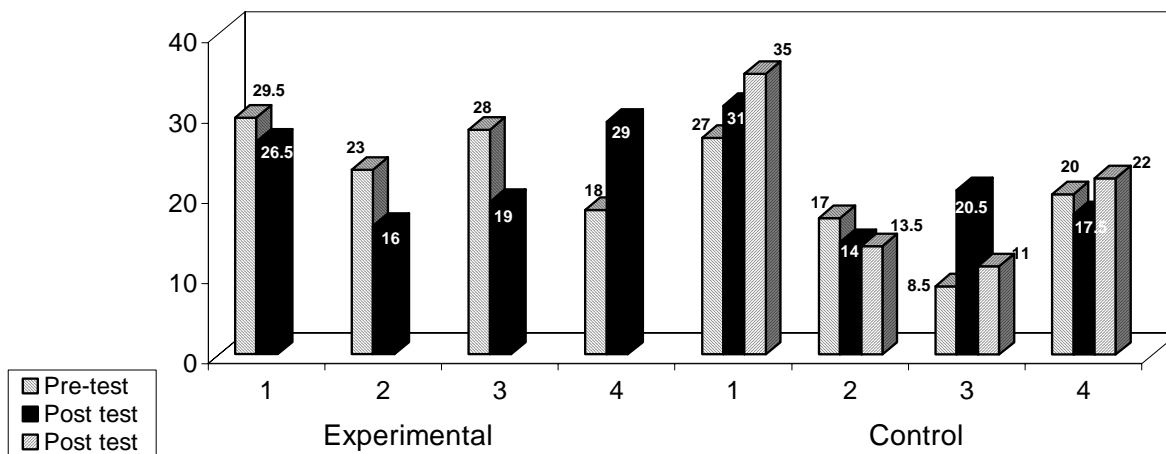


Figure 5.11 Rey Individual scores - Delayed Recall Scores.

Rey Complex Figure: Delayed Recall Scores



5.2.4 Trail Making Test A and B

The test score indices measured for this test were time in seconds and total errors obtained on both trails A and B of the test.

Means and standard deviations measured for the first set of scores are given in table 5.7.

Table 5.7 Time in seconds and total errors obtained on trail A and trail B of the test of the experimental group with and control group without the therapeutic horse riding intervention.

Category	Ex group with THR Mean (SD) N=4	Cont group without THR Mean (SD) N=4	P-Value
Trail A Time in sec	7.5000 (43.9204)	3.2500 (22.0057)	0.7728
Trail A Total Errors	0.2500 (0.5000)	-0.5000 (1.0000)	0.1859
Trail B Time in sec	-11.7500 (14.3614)	3.5000 (15.3297)	0.1441
Trail B Total Errors	0.0000 (1.4142)	0.5000 (1.0000)	0.8770

No significant differences were measured.

On analysing the various means a difference was found between the two groups. The experimental group showed a higher average on trail B and the control group on trail A of the test. Once again the results were not in the expected direction, as it was expected that the experimental group would have achieved higher averages on both trails of the test as they had received the therapeutic horse riding intervention. However, these differences were not big enough to measure a significant difference.

When the individual test scores were analysed with graphs for each participant of the experimental group with the intervention, and of the control group without the intervention, it was noted that participants 2 and 3 of the experimental group obtained a slower time in completing trail A. However, the rest of the group participants all completed the trail faster and either improved slightly or scored the same total of errors. Participants 2 and 4 of the control group both obtained slower times for this trail. All participants in this group completed the trail faster and scored less total errors, except for participant 4 who made more errors in the post-test of this trail. For trail B of the test, participants 1, 2 and 4 of the experimental group took longer to complete this trial, whereas participant 3 improved his time. Participant 1 made more errors in this trail, whereas all the other participants of this group improved in that they reduced their

total error scores. For the control group, participants 2 and 4 obtained slower time scores on this trail, although all the participants in this group made either the same or less total errors. Participant 4 of the control group obtained slower times on both trails and made more errors on trail A, and participants 2 of the control group and 2 of the experimental group both had slower time scores for both trails, which, therefore, may be indicative of poor selective attention and cognitive shift abilities measured by this test. This is the inability to shift set in an ongoing activity (e.g. from numerical to alphabetical sequencing). However the individual improved scores could once again be related to the intervention received, even if they were not big enough to show a significant difference. Further possible reasons for these scores are discussed in chapter 6. (See figures 5.12 – 5.15 for individual scores obtained.)

The second group of scores is for the experimental and control group after they had both received the therapeutic horse riding intervention. Means and standard deviations for the group for each indice measured are given in table 5.8.

Table 5.8 Time in seconds and total errors obtained on trail A and trail B of the test for the experimental and control group with the therapeutic horse riding intervention.

Category	Ex and Cont with THR Mean (SD) N=8	P-Value
Trail A Time in sec	6.7500 (30.2832)	0.7422
Trail A Total Errors	0.2500 (0.8864)	0.7500
Trail B Time in sec	6.5000 (36.6333)	0.9453
Trail B Total Errors	0.1250 (1.4577)	1.0000

No significant differences were measured.

When the graphs for each participant were analysed individually for trail A, the following was noted: all the participants in the control group completed this trail in a faster time and obtained the same score for total errors as in the pre-test. Participant 3, however, showed a slight increase on total errors made, but this increase was too small to be of significant value. For trail B the participants completed the trail in a faster time and also showed either improved or more or less the same total error scores. Participant 4 obtained a slower time to complete this trail after but maintaining his time score for trail A and made fewer errors for both parts of the test. Thus, after considering his first set of scores without the intervention, these scores could possibly indicate improvement in certain frontal lobe functions, such as visual scanning and conceptual tracking. Further, as previously discussed, on trail A of the test, the experimental group participants 2 and 3 obtained slower scores, whereas the rest all improved or showed more or less the same score for total errors. For trail B, participants 1,2 and 4 took longer to complete the trail, but participant 3 improved his time. This group also all improved their scores for total errors, except for participant 1 who made more. Once again the improved scores were not big enough to show a significant difference, but could be attributed to the intervention received. Further possible reasons for these scores are discussed in chapter 6. (See figures 5.12 - 5.15 for individual scores obtained.)

Figure 5.12 Trails Individual scores: Trail A - Time in seconds.

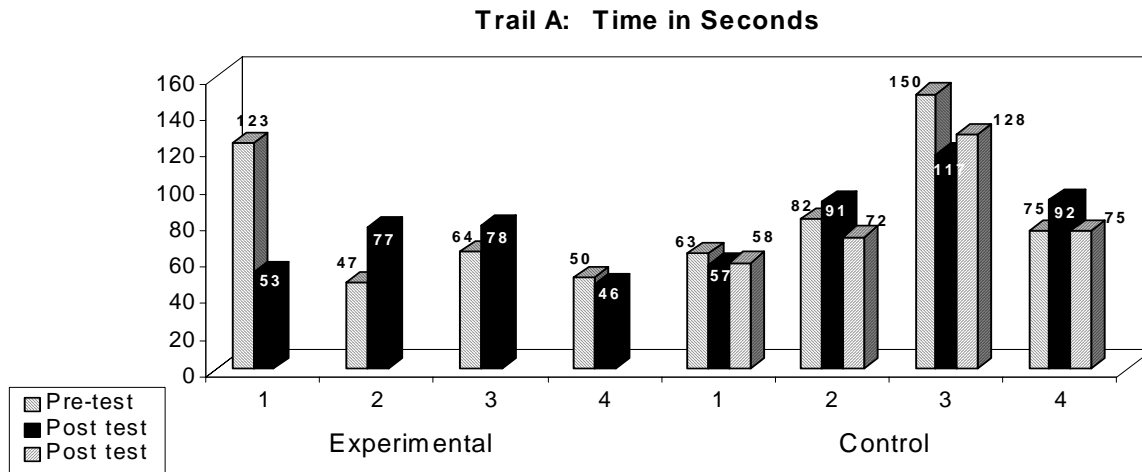


Figure 5.13 Trails Individual scores: Trail A - Total errors.

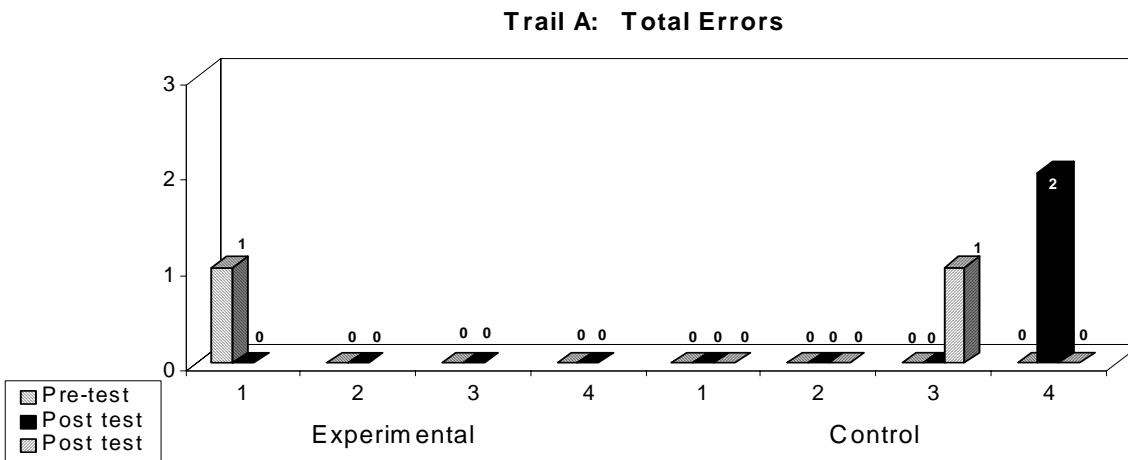


Figure 5.14 Trails Individual scores: Trail B - Time in seconds.

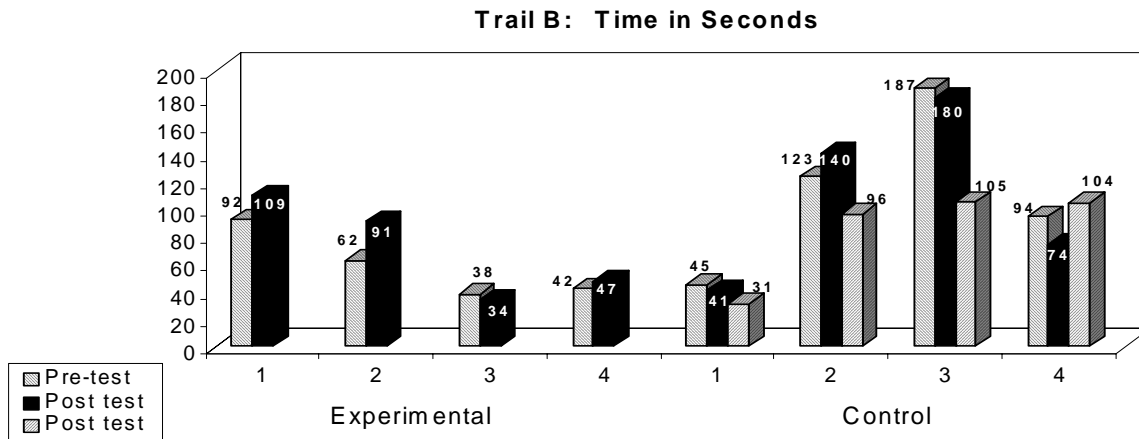
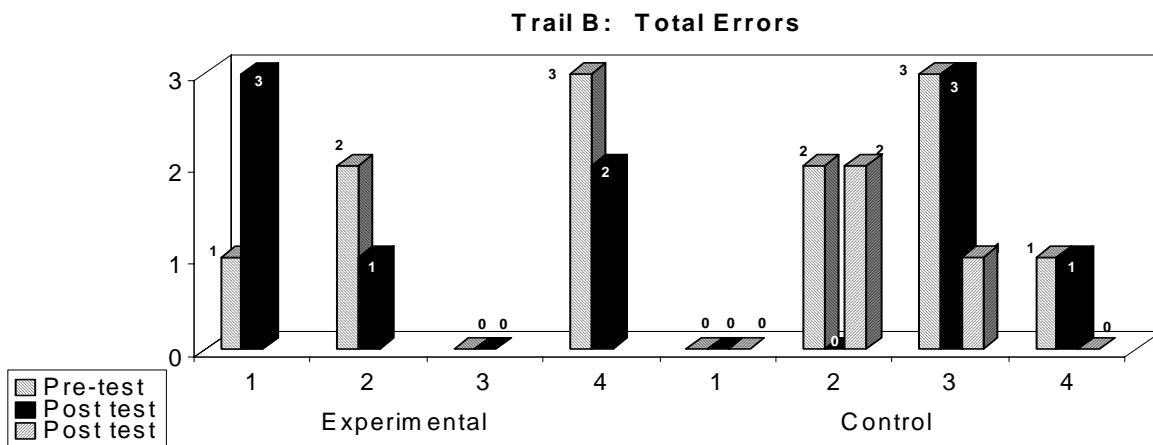


Figure 5.15 Trails Individual scores: Trail B - Total errors.



5.2.5 Raven’s Standard Progressive Matrices

The scores that were used are the overall total correct responses obtained on sets A, B and C of the test.

Means and standard deviations measured for the first set of scores are given in table 5.9.

Table 5.9 Correct responses in the Raven’s test for the experimental group with and the control group without the therapeutic horse riding intervention.

Category	Ex group with THR Mean (SD) N=4	Cont group without THR Mean (SD) N=4	P-Value
Correct Responses	-1.5000 (3.1091)	-2.2500 (4.0311)	0.6631

No significant difference was measured.

When the means of both groups were analysed, the experimental group obtained a higher average on this indice measured. This indicates that

the results were in the expected direction, because the experimental group had received the therapeutic horse riding intervention. However, the difference between the groups was not big enough to indicate a significant difference.

When the individual test scores were analysed with a graph for each participant of the experimental group with and the control group without the intervention, the following was noted: all the participants in the experimental group showed an improvement on their correct responses from the pre-test to the post-test, except for participant 1 who made fewer correct responses. The control group participants also all showed either the same score or improvement on their correct response score, however participant 2 showed a slightly lower score. Although the scores of participant 1 of the experimental group and participant 2 of the control group weren't big enough to show a significant difference, their scores could be an indication of a possible intellectual or conceptual deficiency (learning from immediate experience with problems) measured by this test. Further possible reasons for the scores obtained are discussed in chapter 6. (See figure 5.16 for individual scores obtained.)

The second group of scores was for the experimental and control group after they had both received the therapeutic horse riding intervention. Means and standard deviations for the group for each indice measured appear in table 5.10.

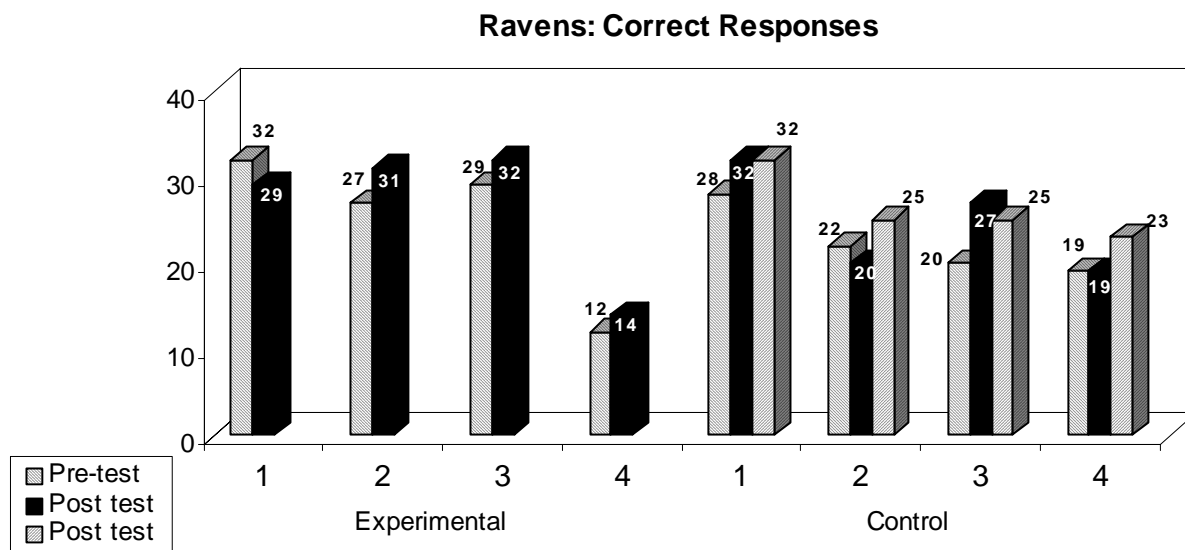
Table 5.10 Correct responses for the test for the experimental and control group with the therapeutic horse riding intervention.

Category	Ex and Cont with THR Mean (SD) N=8	P-Value
Correct Responses	-1.6250 (2.9731)	0.1563

No significant difference was measured.

When the graphs for each participant were analysed individually, scores for the control group indicated that all participants improved on their scores after subjection to the therapeutic horse riding intervention. Whereas, as previously discussed, the entire experimental group improved on their correct responses scores, except for participant 1 who obtained a slight lower score. Thus, these improved scores although not big enough to indicate a significant difference, can once again be related to the intervention received. Further possible reasons for these scores are discussed in chapter 6. (See figure 5.16 for individual scores obtained.)

Figure 5.16 Raven's Individual scores - Correct responses.



5.2.6 Symbol Digit Modalities Test

The scores that were used were for the correct written and verbal substitutions.

Means and standard deviations measured for the first set of scores are given in table 5.11.

Table 5.11 Correct written and verbal substitutions for the Symbol Digit Modalities Test for the experimental group with and the control group without the therapeutic horse riding intervention.

Category	Ex group with THR Mean (SD) N=4	Cont group without THR Mean (SD) N=4	P-Value
Correct Written Subs	-8.0000 (2.9439)	2.0000 (9.8658)	0.1081
Correct Verbal Subs	-3.2500 (12.5532)	-5.2500 (7.7190)	0.8845

No significant differences were measured.

When the various means were analysed, a difference was found between the indices measured. The experimental group obtained a higher average for correct verbal substitutions, whereas the control group obtained a higher score for correct written substitutions. Thus, the results were not in the expected direction: an overall higher average was expected for the experimental group because they had received the therapeutic horse riding intervention. However, these differences were not big enough to indicate a significant difference.

When the individual test scores were analysed, with graphs for each participant in the experimental group with and the control group without the intervention, the following was noted: all the participants in the experimental group showed an improvement on both written and verbal

parts of the test, except for participant 3 who obtained a lower score on correct verbal substitutions. These improved scores could be attributed to the intervention received. However, participants 1, 2 and 3 in the control group showed lower scores on written and verbal substitutions, which might be indicative of dysfunctions in visual-associative learning ability, psychomotor/response speed, visuomotor integration and co-ordination measured by this test. Further possible reasons for these scores are discussed in chapter 6. (See figures 5.17 and 5.18 for individual scores obtained.)

The second group of scores were for the experimental and control group after they had both received the therapeutic horse riding intervention. Means and standard deviations for the group for each indice measured are given in table 5.12.

Table 5.12 Correct written and verbal substitutions for the Symbol Digit Modalities Test for the experimental and control group with the therapeutic horse riding intervention.

Category	Ex and Cont with THR Mean (SD) N=8	P-Value
Correct Written Subs	-8.3750 (6.1630)	0.0078 *
Correct Verbal Subs	-6.7500 (14.0687)	0.2500

*Significant, $p < 0.05$

A significant difference was measured at a 5% level of significance ($p < 0.05$) for the correct written substitution scores ($p = 0.0078$). All the participants of both groups improved on their scores for this part of the test, except for participant 1, who obtained a lower score. This participant's score may be related to a visual-associative learning and visuomotor integration disability, problem areas often associated with

Tourette syndrome patients. Thus, the results were in the expected direction, with most participants improving their scores possibly attributed to the intervention received.

When the individual scores were further analysed for each individual participant, the following was noted. After both groups had received the therapeutic horse riding intervention, all the participants improved on their scores for both categories of the test, except for participant 3 of the experimental group, as discussed previously for the verbal part of the test, and participant 3 of the control group who obtained lower scores for both parts. Possible reasons for these results are discussed in chapter 6. (See figures 5.17 and 5.18 for individual scores obtained.)

Figure 5.17 Individual scores - Correct written substitutions.

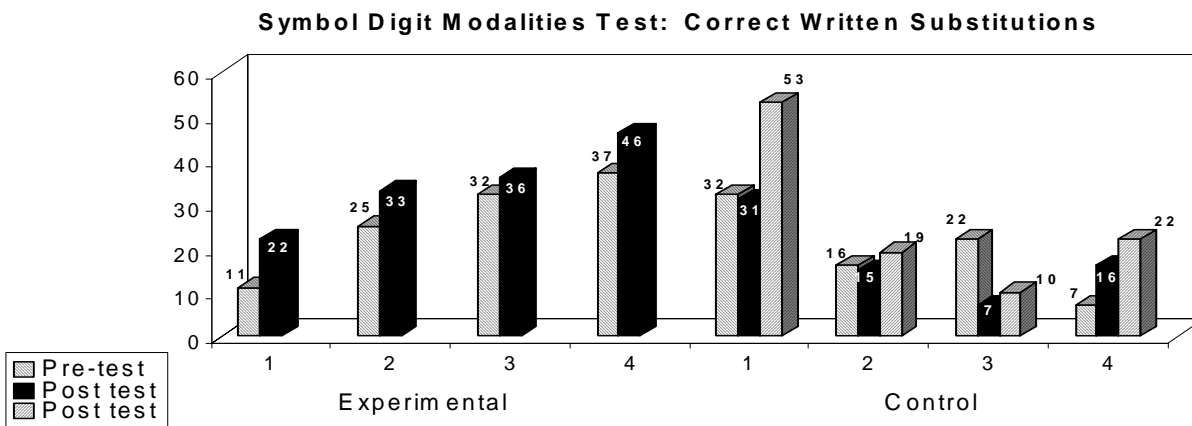
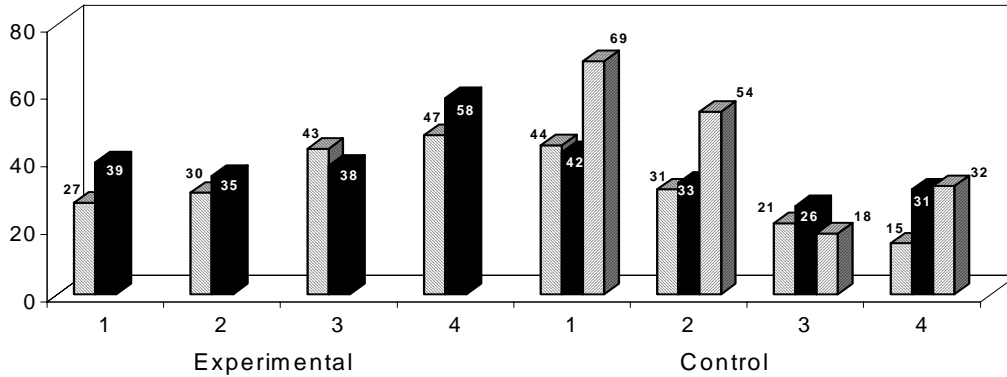


Figure 5.18 Individual scores - Correct verbal substitutions

Symbol Digit Modalities Test: Correct Verbal Substitutions



5.3 Qualitative results

Important additional information was obtained through the assessment of the qualitative data that could support certain participants' neuropsychological test results that were not in the expected direction. This data was obtained through the use of the Lahey Child Behaviour Checklist, the Rey-Osterrieth Complex Figure Test and the required pre- and post-test evaluation for the equi-therapy on its own.

The Lahey Child Behaviour Checklist was used to determine possible changes in behavioural and emotional patterns of the participants before and after they received the therapeutic horse riding intervention. The parents of the participants completed these checklists. From the observations of the parents, the following combined changes were noted for the 8 participants before and after the intervention:

Benefits

- Emotional (self-confidence and self-worth improved – participants became more independent, were more relaxed and focused).
- Socialisation abilities improved (made more friends and adjusted better, showed more respect towards parents and other family members).
- Hyperactive and destructive behaviour minimised (less aggressive/hostile towards others and in deliberately harming self/animals).
- Academic achievements improved in certain subjects/areas (parents also noted specific improvements in concentration and memory patterns).
- Co-ordination improved and clumsiness was reduced.
- Certain behaviours such as lying and cheating, overeating, sleep-talking, constant crying and whining improved for some of the participants.
- Physical problems without a known medical cause, such as nausea, vomiting, stomachache or cramps lessened for some of the participants.
- Sleeping habits also improved for some of the participants.
- For 2 of the participants, their tic behaviour lessened. Medication was stopped for 1 after the riding, and the other was to receive half his normal dosage.

Negatives

The negative patterns were often just the opposite of the positive patterns mentioned, however the following aspects could be singled out:

- Restlessness.
- The use of obscene language or swearing.
- Behaving like the opposite sex.
- Hearing voices (hallucinations).

- Having an imaginary friend and companion.
- Perfectionism and self-centredness.
- Obsessions with safety – everything must always be locked and secured.

Qualitative information obtained through the Rey-Osterrieth Complex Figure Test was obtained according to either a 'frontal' or 'normal' observation of the participant's copied drawing. This was achieved through the administrator's reproduction of the subject's drawing, the random order in which components of the figure were drawn (lack of planning and organisation), inclusion of components not in the original figure (disinhibition), or retracing of components once drawn (motor perseveration). A drawing displaying any or all of the above characteristics was classified as 'frontal'. A 'normal' performance was any copy that showed none of the above characteristics nor any other errors to a greater extent (Walsh, 1987). The overall observation made was that the most of the participants, whether they had received the therapeutic horse riding intervention or not, were characterised by 'frontal' profiles. Although 3 participants did show an improvement from a 'frontal' to a 'normal' profile after receiving the intervention. However, another participant went from a 'normal' to a 'frontal' profile. Possible reasons for this are discussed in chapter 6.

The pre- and post-test evaluation for the equi-therapy on its own supplied information with regard to the executive functioning and sensory integration simulation of the participants. The following tests were administered by a qualified occupational therapist. Clinical Observations of Dr A.J. Ayres, the Southern California Sensory Integration Test, Dr H. Gardner's Test of Visual-Perceptual Skills and his Developmental Test for Visual Perception, the Beery Test - a Developmental Test of Visual-Motor

Integration, and the Brain Profile Test Derived from Kinesiology. As 2 or 3 of these mentioned tests coincided with the assessment of various executive functions, such as visuospatial/visuomotor constructional abilities, together with the sensory integration assessments, data were obtained that supported this study. However, these data were not the main focus of the study, but merely used as additional information. Results observed were quite consistent with aspects of the qualitative data obtained through the Lahey Child Behaviour Checklists. The latter representing the emotional and personal changes observed in the participants before and after they received the therapeutic horse riding intervention. It is interesting that the experimental group showed a slightly better improvement here, than the control group. Results obtained for the tests administered indicated improvements on perceptual components, visuomotor integration and visual-associative learning for some of the participants. However, various deficits on visuospatial constructional abilities, visuomotor integration, psychomotor response speed and visual-associative learning abilities were also found. Thus, these results indicated improvements in emotional and behavioural features, indicating a possible link between emotion and cognition for Tourette syndrome patients. Possible implications of these results for this study are discussed in chapter 6.

5.4 Conclusion

The results obtained were not always in the expected direction to support the hypothesis made. The experimental group were expected to obtain higher post-test scores with the therapeutic horse riding intervention than the control group without, which was not always indicated. The same was, however, implied for the results obtained after all the participants had received the therapeutic horse riding intervention, with some participants

improving their scores and others not. Significant results were obtained on the Wisconsin Card Sorting Test, Stroop Colour Word Test and Symbol Digit Modalities Test. As for the qualitative observations, they indicated certain improvements in the expected direction to support the hypothesis made, however the results also indicated the influence of certain emotional and behavioural aspects, which may be related to cognitive deficits for some of the participants. Possible reasons for these results are discussed in chapter 6.

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Parent Indemnity Form

**Equi-Therapy (therapeutic horse riding) research over the period
04 September 2001 - 17 April 2002**

Aim of the research: to evaluate the effect of Equi-therapy on the executive functioning of children with Tourette's syndrome. Executive functions basically being the motivational, planning and executional abilities of any individual.

The following specific details will be evaluated prior to and after 3 months of physical horse riding therapy has been completed:

- *Planning & Organisational ability
- *Problem Solving
- *Attention
- *Intellectual efficiency (IQ)
- *Behavioural & Social Functioning

The evaluation of the above-mentioned details will consist of basic psychometric tests that will be administered for a period of no longer than 1 hour and 30 minutes per child - the researcher will supply the dates and times as to when your child will be evaluated. *Parents will also be requested to complete behavioural checklists before and after the completion of the program. (Please feel assured that all acquired information will be handled with the strictest of confidence)

The children will ride once a week for 1 hour on Tuesdays from 16h30-17h30 at the South African Therapeutic Riding Association (SATRA), Willow Glen, Pretoria. If children have a transport problem arrangements may be made to attend a different class at a more appropriate time.

Important: You are please requested to inform the researcher if your child may start with any other therapies during the research period or if medication currently being taken is suspended or altered. This information can contribute to the study not being compromised in any way.

Personal Details required for research:

First name: _____

Surname: _____

Age: _____

Sex: _____

Home language: _____

Time since diagnoses: _____

Medication - specify: _____

Previous riding experience: _____

Physical address: _____

Parent/Guardian Details Required for Research:

First name & surname: _____

Contact number (a/h): _____

(Cel): _____

Transport problem and will require a different class

*Yes: _____ *No: _____

Additional comments or questions:

Signature parent/guardian

Date

Parent Indemnity Form

Equi-therapy (therapeutic horse riding) research over the period 04 September 2001 - 17 April 2002

Aim of the research: to evaluate the effect of Equi-therapy on the executive functioning of children with Tourette's syndrome. Executive functions basically being the motivational, planning and executional abilities of any individual.

The following specific details will be evaluated prior to and after 3 months of no horse riding therapy as well as after a further 3 months of physical horse riding therapy has been completed:

- *Planning & Organisational ability
- *Problem Solving
- *Attention
- *Intellectual efficiency (IQ)
- *Behavioural & Social Functioning

The evaluation of the above-mentioned details will consist of basic psychometric tests that will be administered for a period of no longer than 1 hour and 30 minutes per child - the researcher will supply the dates and times as to when your child will be evaluated. *Parents will also be requested to complete behavioural checklists before and after the completion of the program. (Please feel assured that all acquired information will be handled with the strictest of confidence)

As your child will be partaking in the group that will not physically be riding in the program for the first 3 months, it is requested that he/she not take part in any form of horse riding for the 3 month period so that the study may not be compromised in any way. After this period the children will ride once a week for 1 hour on Tuesdays from 16h30-17h30 at the South African Therapeutic Riding Association (SATRA), Willow Glen, Pretoria. If children have a transport problem arrangements may be made to attend a different class at a more appropriate time.

*Furthermore you are please requested to inform the researcher if your child may start with any other therapies during the research period or if medication currently being taken is suspended or altered. This information can contribute to the study not being compromised in any way.

Personal Details required for research:

First name: _____

Surname: _____

Age: _____

Sex: _____

Home language: _____

Time since diagnoses: _____

Medication - specify: _____

Previous riding experience: _____

Parent/Guardian Details Required for Research:

First name & surname: _____

Contact number (a/h): _____

(Cel): _____

Transport problem and will require a different class

*Yes: _____ *No: _____

Additional comments or questions:

Signature parent/ guardian

Date