THE EFFECT OF A WATER-BASED PROGRAMME ON THE MOTOR PROFICIENCY OF CHILDREN WITH DEVELOPMENTAL COORDINATION DISORDER (DCD)

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DEDICATION

To Mario Scoccio

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ABSTRACT

This study determined the effect of a water-based programme on the motor proficiency of children with Development Coordination Disorder (DCD). The water-based programme promoted an alternative environment for DCD children, involving all dimensions of movement. Thirty-one (31) children from Port Elizabeth participated, with an experimental group (n=15) following the eight-week water-based programme, while a control group (n=16) carried on with daily activities. Motor proficiency was measured during three tests, utilizing the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP). Results indicated positive effects of the intervention on all the variables of the BOTMP ($p < 0.05$). Confirming this, three variables obtained practical significance with Cohen's $d > 0.8$, and one with $0.2 < d < 0.8$. At the end of the three-month duration of the study, the experimental group indicated better performances at the end of the study than at the start, thereby confirming the positive and lasting effect of the water-based intervention programme. Therefore, the use of a water-based programme in improving motor proficiency is supported. However, implementation of the programme over a longer period is recommended.

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THE PROBLEM

1.1 INTRODUCTION

Expectations for children in South Africa have become extremely high with the development of the country, politically and socio-economically (Padayachie, Atmore, Biersteker, King, Matube, Muthayan, Naidoo, Plaatjies and Evans, 1994). In the school setting, where teachers are few and numbers of children in one class are increasing, the child with motor problems is often regarded as being lazy, uninterested or even rebellious to the school system. Such children are nevertheless expected to participate and perform in the academic and sport curriculum. In pre-school groups, poorly coordinated children first become seriously challenged when performing physical tasks to which they are unequal (Gubbay, 1975). They then might become frustrated from constant failure and retreat from performing manual tasks. Problems increase in earlier school years when children are expected to look after their own personal needs and to cope with the demands of motor skills both within the classroom and on the playground. By middle childhood, most children should have accomplished a variety of manual activities (drawing, modelling, general constructional hobbies).

Poorly coordinated children occupy themselves with activities such as watching television, rather than showing interest in physical activities due to the frustration and sense of failure that they felt before. This social withdrawal forces such children out of the popularity circles and they experience consequent prejudice.

Poorly coordinated children for example have been found to:

1) be delayed in the acquisition of culturally normative motor skills and show a wide range of motor coordination difficulties (Hoare, 1994; Sprinkle and Hammond, 1995; Visser, 2003),

2) have difficulty in learning new complex tasks (Missiuna, 1994),

3) be able to learn a movement but not be able to apply it in a skilled fashion (Missiuna, 1994), and

4) be more variable than their peers when performing motor tasks (Missiuna, 1994).

These children, therefore, do not have the opportunity to develop adequately and proficiently because they are considered as either lazy and insolent or withdrawn and lacking interest. This shortage of opportunity is mainly due to the general lack of knowledge that such a coordination disorder exists in society (Henderson and Henderson, 2002). The term used to define this developmental delay is called Developmental Coordination Disorder or DCD first described by the DSM-IV in 1994 (Henderson and Henderson, 2002).

The reversibility of the many dysfunctions associated with child development has been investigated but only limited research has been done on intervention programmes that are currently used to address the specific aspects of child development dysfunctions (Missiuna, 2001). Thus, it has become imperative to try to understand and be able to identify the scope of the problem and to effectively help the children experiencing these difficulties.

Missiuna (1994) found that poorly coordinated children benefited more directly from repeated exposures to a specific task. Improvement was due to individual children learning gradually to programme and then to execute the task quickly. The differences between poorly coordinated children and control groups as indicated in certain studies (Missiuna, 1994; Henderson and Henderson, 2002), concern slowness of movement, this being during both learning the task and execution. They found that poorly coordinated children benefited more from the practice of a specific skill.

Pless and Carlsson (2000) agreed as they identified the use of specific-skill or task-specific instruction as a beneficial approach to intervention programmes for children

with coordination difficulties (DCD). This approach is based on the assumption that specific motor control and motor learning processes underlie skilled movement. The key to successful motor training programmes is found in combinations of correctly performed practice of functional skills, appropriate repetition, and sufficient guidance and time to facilitate skill retention and generalisation (Pless and Carlsson, 2000).

The task-specific approach could therefore be incorporated in a water-based programme, teaching children to move through water using coordinated movement. Moving limbs in a coordinated manner when learning swimming skills for example, can offer children the opportunity to practise functional motor programming, at the same time incorporating repetition of movement with sufficient guidance. Teachers and parents have started to realise the potential of water for their children, including those with developmental disorders.

As early as 1939, researchers studied the development of skills in children in the medium of water (Erbaugh, 1986). Erbaugh (1986) noted that developing swimming skills in children contributed to the underlying development of the central nervous system, which is the backbone to the underlying mechanisms of motor proficiency. Langendorfer (1990) reported how the view on aquatic programmes for children has changed since the 1970s. Critics softened their objections to the view that water programmes can enhance child development, and ultimately acknowledged the remedial benefits of water (Langendorfer, 1990). In addition, research on early aquatic instruction increased such that, in 1985, the National Aquatic Journal (United States of America) started a series of research-based articles on aquatics for children. During 2001, researchers summarised the use of aquatic therapy as an intervention option for children with neuromuscular and musculoskeletal disorders (Dumas and Francesconi, 2001). They also noted that there seemed to be a scarcity of literature related to aquatic therapy for children.

At present, research on specific intervention methods is limited and even more so regarding intervention programmes utilizing the medium of water. A study that focuses on a water-based programme as a method of remediating DCD, therefore seems justified.

1.2 STATEMENT OF THE PROBLEM

Children with Developmental Coordination Disorder (DCD) are a distinct group often referred to as clumsy, lazy, hyperactive, rebellious or even lacking confidence, and they do not have the motor competence necessary to cope with the demands of everyday activities (Mandich, Polatajko, Macnab and Miller, 2001). The distress, heightened anxiety, low self-esteem and secondary social and behavioural problems observed frequently in these children, have been well documented (Armitage and Larkin, 1993; Willoughby and Polatajko, 1995; Fox and Lent, 1996; Visser, Geuze and Kalverboer, 1998; Hadders-Algra, 2000; Skinner and Piek, 2001; Henderson and Henderson, 2002; Peens, Pienaar and Nienaber, 2004). Being unable to perform activities requiring movement can have far-reaching consequences for the educational progress of this group of children, their social relationships and even self-esteem (Skinner and Piek, 2001; Peens *et al*., 2004).

A high incidence of associated problems in a wide range of functions typically occurs with DCD. Universally, this is a disorder of motor coordination and it has the following diagnostic criteria (Diagnostic and Statistical Manual of mental disorders, 4th ed, 1994 in Pless and Carlsson, 2000):

- Performance in daily activities that require motor coordination is substantially below that expected given the person's chronological age and measured intelligence. This is manifested by marked delays in achieving motor milestones.

- The disturbance mentioned above significantly interferes with academic achievement or activities of daily living.

- The disturbance is not due to a general medical condition and does not meet the criteria for a pervasive developmental disorder.

- If mental retardation is present, the motor difficulties are in excess of those usually associated with it.

The incidence of DCD among children is 6% of the normal primary school age population (6 to 12 years) (Pless and Carlsson, 2000). Fox and Lent (1996) estimated a prevalence of DCD ranging from 5% to 15% and that boys are more commonly affected. The severity of the problem according to Losse, Henderson, Elliman, Hall, Knight and Jongmans (1991) is reflected in the fact that children clumsy at the age of six, still had poor motor skills, poor self-esteem, and significantly poor academic performance at the age of 16. Pless, Carlsson, Sundelin and Persson (2002) concluded that most children with motor deficiencies continue to have such difficulties. Children are affected very early in life but it only becomes obvious that they might have a developmental delay as expectations for complex motor skills increase.

Resources for children with special needs are limited (Henderson and Henderson, 2002). Meticulous evaluations of intervention are essential for both theoretical and practical reasons. Parents and teachers, as well as children, seek for interventions to alleviate DCD. Intervention techniques for children with DCD, or anyone suffering a developmental delay, are varied and the efficacy of these interventions is controversial. The conservative treatment is usually physical or occupational therapy that is often recommended, despite limited evidence of efficacy (Fox and Lent, 1996). The very nature of DCD complicates the matter further. Under the umbrella term of Developmental Coordination Disorder (DCD), children have problems related to almost any sensory or motor skill imaginable (Visser, 2003). Treatment programmes need therefore to consider children's individual needs and cater for the variability of each child's difficulties.

Overall, developmental disorders such as DCD, Deficits in Attention, Motor Control and Perception (DAMP) and Attention Deficit/Hyperactivity Disorder (ADHD) are very common among school-aged children (Pienaar, 1995; Kadesjo and Gillberg, 1999; Kadesjo and Gillberg, 2001). These disorders seem to all have similar trends and symptoms and their etiology seems to be influenced by hereditary, neuropathogenic and social factors. All these disorders present the child with some sort of delay, although on different levels. The researcher is of the opinion that a water-based intervention programme that uses a task-specific approach could not only improve

the motor proficiency of children with DCD but it could also provide fun and enjoyment to the participating children.

1.3 AIM AND OBJECTIVES OF THE STUDY

The aim of this study was accordingly:

- to determine the effect of a water-based programme on the motor proficiency of 6-12 year-old children identified with DCD or poor motor proficiency.

In order to achieve the above-mentioned aim the following objectives are relevant:

- to describe the motor proficiency of an experimental and control group of 6-12 year-old children.

- to compare the motor proficiency of the experimental and control groups before, immediately after and one month after an eight-week water-based programme.

1.4 DELIMITATION OF THE STUDY

In order to achieve the objectives of this study, the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) was used to assess and establish the motor proficiency of the subjects involved. Test 1 was used to determine the initial motor proficiency scores for the total sample. Subsequently these subjects were divided into an experimental and a control group. The experimental group completed an eight-week water-based activities programme, whilst the control group carried on with normal daily activities. Immediately after completion of the intervention programme, motor proficiency was evaluated for both the experimental and control groups, again using the BOTMP (Test 2). One month later, after continuing with normal daily activities, 17 children, of whom eight were from the experimental group and nine from the control group, were

tested in exactly the same way as in Test 1 and Test 2. This enabled the researcher to determine retention of motor proficiency after completion of the programme.

1.5 TERMINOLOGY

The following terms are frequently used in the text:

Developmental Coordination Disorder (DCD):

- A motor performance impairment that is not explicable by the child's age, intellect, or other diagnostic neurological or psychiatric disorders (Diagnostic and Statistical Manual of mental disorders, 4th ed, 1994 in Pless and Carlsson, 2000).

Motor Proficiency:

- Successful accomplishment of motor skills, assuming successful motor development (Maldonado-Duran, Glinka and Lubin, 2002).

Motor Development:

- A process occurring over time with alteration in behaviour with successful motor development leading to motor proficiency (Newcombe, 1996).

The Bruininks-Oseretsky Test of Motor Proficiency (BOTMP):

- A standardized measuring instrument in research, used to assess children's motor proficiency (Bruininks, 1978: 11).

1.6 SUMMARY

This study aims to investigate a possible method of intervention to improve motor proficiency in children with poor motor coordination. Children aged 6-12, who had been identified with DCD, as well as children who had poor motor proficiency scores on the BOTMP, were involved in the study. Research indicated that poorly coordinated children could benefit from repeated exposures to specific tasks as they were found to be slow in executing a movement during the learning process. By the mid-20th century, water-based activities were being incorporated as a method to develop skills of young children. By the Nineties, water-based programmes had become quite popular for their ability to enhance child development. However, resources are still limited for children with developmental delay such as DCD, and little has been done to evaluate water-based programmes as intervention methods to improve motor proficiency.

This study was therefore initiated to test the effect of a water-based activities programme on the motor proficiency of children with DCD. With the completion of the intervention programme, motor proficiency was evaluated for both the experimental and control groups, again using the BOTMP, while a retention test was conducted one month after the programme's completion.

1.7 STRUCTURE AND OUTLINE OF THE DOCUMENT

The rest of this document consists of four more chapters. In Chapter Two, the process and phases of motor development are depicted and the nature of DCD is detailed. Different approaches to intervention are discussed and assessment measures of motor proficiency are reviewed. The methods and procedures utilized in this study are reflected in Chapter Three. The latter reflects the design and layout of the study and the procedures followed before, during and after the intervention programme. The results of the study have been statistically analysed and the outcome reflected in Chapter Four. Conclusions regarding the achievement of the objectives of the study are indicated in Chapter Five and finally, recommendations for future studies are provided.

CHAPTER TWO

LITERATURE REVIEW

2.1 INTRODUCTION

As background to this study, it is necessary to review and draw upon what work has already been carried out regarding children with difficulties affecting motor proficiency and ways of assisting such children to overcome their problems through alternative forms of treatment.

Motor proficiency is defined in this study as the successful accomplishment of motor skills, facilitating successful motor development. To perform motor skills, children need to grow in a healthy manner while adapting successfully to their environment. However, when a delay in motor development occurs, motor skills are often affected, also creating problems in other areas of functioning. Developmental Coordination Disorder (DCD) is one such delay that is still confusing researchers on its cause and resulting in the creation of various theories with proposed answers. In addition to its theorised etiology, the heterogeneous nature of DCD is vast and thus researchers are determined to find subtypes in order to obtain results that are more significant.

In order to understand the nature of DCD, it is explained in this chapter through various theories, discussions and methods of intervention. Treatment for a child with DCD has often been limited to conventional methods, but incorporating different approaches. These approaches to intervention are examined and included to form an alternative method of intervention. A water-based activities programme is introduced as a fun, new approach that enables children to explore another environment whereby motor proficiency can be achieved. A brief discussion follows of two of the most common measuring tests for use in assessment during research.

2.2 MOTOR DEVELOPMENT

Through time comes change, and positive change implies development. Latash (1998) explains development as a lifelong process of change. Gallahue (2000: 266-279) agrees that development is a process occurring over time with alteration in behaviour. Typical development takes on natural phases for children to pass through and it is normally through a child's not achieving these phases that a delay in development is recognised. In order to produce motor proficiency, children obviously need to develop their motor skills properly.

Motor development occurs therefore when children can change or vary their movement capabilities, while adapting to their environment. According to Newcombe (1996), this change usually results in new, improved ways of behaviour that becomes better organized, more complex, more stable, more competent, and more efficient. Newcombe (1996) further describes the modifications that children experience in motor development, as having three-fold characteristics: First, changes in development appear to be universal, meaning all children develop in the same way regardless of their culture or experiences. Secondly, individual differences need to be explained in order to answer questions about the decision making of individual children. Thirdly, the environment influences behaviour and its influence on motor development need to be taken into consideration. Environmental factors create opportunities for different behaviour and its development.

According to Gallahue (2000: 266-279), movement acquisition can be viewed from two perspectives, either as a process or as a product. Firstly, as a process, underlying mechanisms influence motor development. Theorists utilizing the dynamic systems approach, endorse this view. Secondly, as a product, development of motor skills can be studied in a descriptive way, such as by describing the phases of motor development, to create a better understanding of it. This section explores motor development from these two perspectives.

2.3 THE PROCESS OF MOTOR DEVELOPMENT

The functioning of a complex set of structures (the process) is often taken for granted in children developing in a typical way. Smooth and accurate movement requires a well-balanced functioning of input, processing and execution (Maldonado-Duran *et al.,* 2002). The dynamic systems theory introduces development as non-linear and discontinuous, concentrating on individualised movement patterns (Gallahue, 2000: 266-279). The theory views all subsystems as potential contributors to change in motor behaviour that can either promote or restrict development (see section 2.6.4). The two primary subsystems are identified as (1) biological or hereditary factors and (2) environmental or learning factors. In summary, the theory recognizes that development of a specific movement task interacts with both hereditary and environmental factors.

For further understanding of the process of motor development and its underlying mechanisms, the nervous system and its influence on motor development must be taken into account. The structures forming the highly organized, complex network known as the nervous system include the brain and the spinal cord, together with cranial nerves, spinal nerves and sensory receptors.

2.3.1 The nervous system

The nervous system has three basic functions: sensory function, integrative function and motor function. The last mentioned responds to integration decisions (Tortora and Grabowski, 2000: 463-502) using the spinal cord and is the background to the development of movement in the child. The nervous system is composed of two subsystems: (1) the Central Nervous System (CNS) and (2) the Peripheral Nervous System (PNS).

The CNS combines and associates different incoming sensory information and is the source of emotions, thoughts and memories. The PNS is subdivided further into the (1) Somatic Nervous System and (2) the Autonomic Nervous System. The Somatic

Nervous System uses sensory and motor neurons to convey information to and from the brain and limbs respectively, enabling the child to voluntarily stimulate his/her skeletal muscles. Conversely, the Autonomic Nervous System conducts impulses to smooth muscle, cardiac muscle, glands and adipose tissue.

The brain is a continuation of the spinal cord, and consists of four principal parts: brain stem, cerebellum, diencephalon and the cerebrum. The cerebellum detects the discrepancies of movement (actions that are not carried out properly by the individual) and sends feedback to the motor areas to modify the movements. This feedback helps to smooth and coordinate complex sequences. It also regulates posture and balance. In short, the cerebellum makes all skilled muscular activities possible, from catching a ball to dancing.

The basal ganglia of the cerebrum coordinate gross, automatic muscle movements and regulate muscle tone. Generally, the sensory areas of the cerebral cortex receive and interpret sensory impulses, the motor areas initiate movements, and the association areas deal with the more complex integrative functions. The primary motor area coordinates voluntary contractions of specific muscles with electrical stimulation, which results in the contraction of specific skeletal muscle fibres on the opposite side of the body. The cortical area regulates those muscles involved in skilled, complex or delicate movement such as fine motor skills (Tortora and Grabowski, 2000: 463-502).

Adequate movement requires the union of numerous pathways (Tortora and Grabowski, 2000: 463-502; Maldonado-Duran *et al.,* 2002) in the nervous system. The cerebellum and the cerebrum form part of this mechanism. Motor output to the muscles travels down the spinal cord in two descending pathways: (1) direct (pyramidal) pathways and (2) indirect (extra pyramidal) pathways (Tortora and Grabowski, 2000: 463-502). The direct pathways originate in the cerebral cortex and cause precise, voluntary movements of skeletal muscles. The indirect pathways help the body coordinate movements with visual stimuli, maintenance of muscle tone, posture and balance by regulating a response to movements of the head. According to Maldonado-Duran *et al.* (2002), information to the central nervous system is

obtained from the proprioceptive, visual input and alert systems. If these systems do not function properly, the resultant movement may not be smooth and accurate.

2.3.2 Variables of motor development

Some of the building blocks of development can be mentioned together with the neuro-physiology of motor development and are important in the understanding of motor difficulties in children. The main variables in motor development, as summarized by Maldonado-Duran *et al.* (2002), are:

- muscle tone (ongoing activity in the muscles),
- gross motor skills (ability to use large or groups of muscles to carry out an activity),
- fine motor skills (movements of small muscles to act in an organized way),
- muscular strength (the intensity of voluntary muscle contraction),
- motor planning (ability to plan a movement mentally),
- sequencing and speed of movements (the order in which movements should proceed to have an effective outcome), and
- sensory integration, the organisation of the senses.

Each of these variables involves the structures of the nervous system to regulate movement. They form the basis of achieving motor proficiency. If one of these variables is flawed, movement production is altered. As the neurology and the variables provide information about the *process* of motor development, so the next section provides a descriptive outlook on the motor development *product*. Here follow the different phases or task factors of motor development.

2.4 THE PHASES OF MOTOR DEVELOPMENT

The phases of motor development associate with motor development as the product. A descriptive model is used to determine these phases as set out by Gallahue (2000: 266-279; Gallahue and Donnelly, 2003: 37-62).

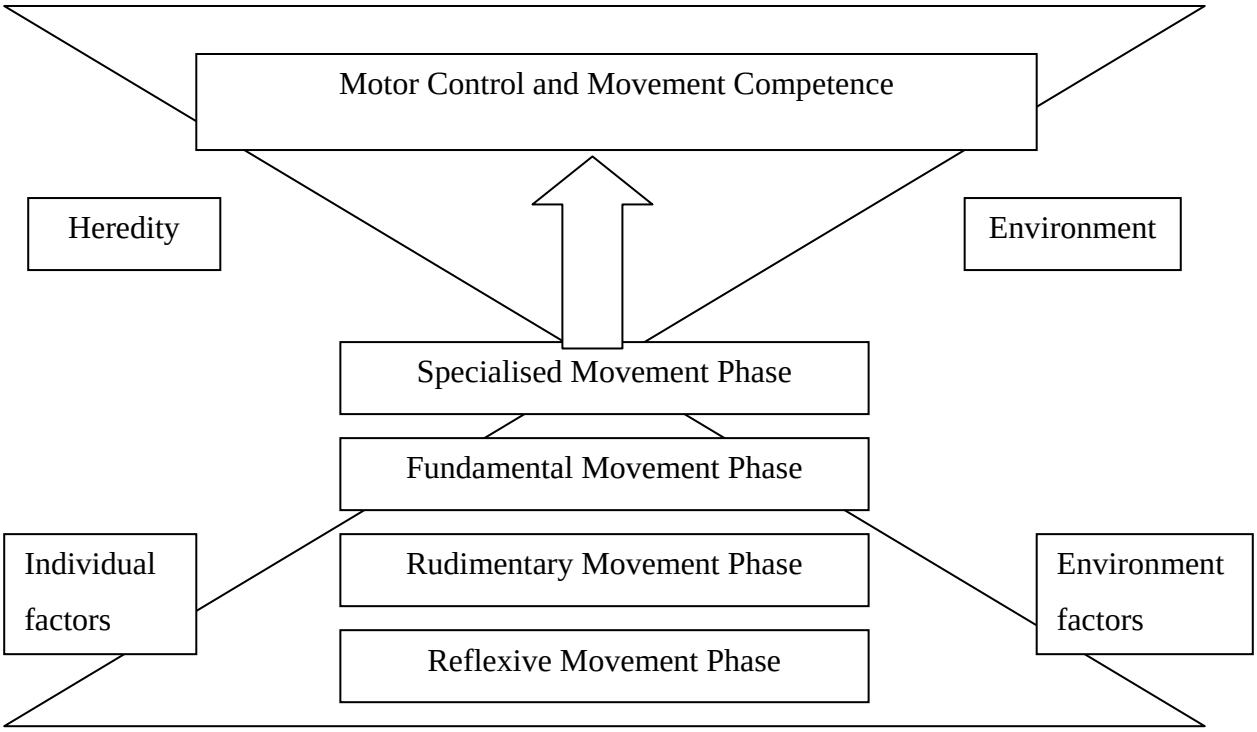


FIGURE 1: GALLAHUE'S LIFE SPAN MODEL OF MOTOR DEVELOPMENT (ADAPTED FROM GALLAHUE, 2000: 269)

The model introduces the different phases as: (1) reflexive movement phase, (2) rudimentary movement phase, (3) fundamental movement phase and (4) specialised movement phase. Each of these phases is presented in a hierarchical order in Figure 1. The latter also depicts the two factors namely heredity and the environment that contribute to the final product of motor proficiency.

2.4.1 Reflexive movement phase

The period of infancy enables the child to discover perceptual and motor characteristics (Craig, 1996: 154-260). This discovery period creates the opportunity for interaction together with the child's environment. Maldonado-Duran *et al.* (2002) state that although primitive reflexes are essential for the development of the infant in the first few months after birth, they can be detrimental to the motor development of the infant if they persist after 6-7 months. Postural reflexes resemble later voluntary actions to support the body against gravity and allow for movement. Gallahue describes reflex activity as the method used by the infant to interact with the

environment (Gallahue and Donnelly, 2003: 37-62) and mentions both primitive reflexes and postural reflexes to be active after birth. It is therefore important that all these reflexes are present when relevant and stimulated in order to ensure effective movement development.

2.4.2 Rudimentary movement phase

The rudimentary movement phase indicates the start of voluntary movements (Gallahue, 2000: 269-279). The rates at which the abilities appear, are variable for each child and rely on biological, environmental and task-specific factors. The process of integrating information from the perceptual and motor systems becomes more significant. By 12 months, the child gains a new perspective when he/she can actively manipulate the environment. Each developing system in the infant supports the other and the first two years of the child's development constitute a complex yet dynamic process (Tortora and Grabowski, 2000: 4).

2.4.3 Fundamental movement phase

Basic movement skills include walking, running, throwing and catching, which are necessary for developing refined movement skills. Children are actively involved in this fundamental movement phase to discover how to perform stabilizing, loco motor and manipulative movements (Gallahue, 2000: 269-279). Three separate stages evolve in the fundamental phase. The initial stage signifies the child's first attempts to perform a goal-oriented movement. However, the child still has poor rhythm and coordination. During the next stage, the elementary stage, the child produces movements that are better coordinated, yet still exaggerated (Gallahue, 2000: 269-279). Eventually, the mature stage sees the child achieving efficient, coordinated and controlled fundamental movements. Conversely, Gallahue mentions that many children fail to achieve this mature movement and do not go beyond the elementary stage (Gallahue and Donnelly, 2003: 37-62).

2.4.4 Specialized movement phase

As the child advances in age and maturity, he/she becomes specialized in movement production. This phase represents refined abilities in stability, loco motor and manipulative skills. Activities are added to the fundamental movements of before. According to Gallahue (2000: 277), from the age of seven, children begin to apply fundamental skills to the performance of accurate and controlled specialised skills. Between the ages of 10 and 13, conscious decisions are being made for participation in specialized activities. Their decisions are based on the factors of the task, their abilities and the environment that either restrains or adds to their chance of success. Furthermore, the specialized movement phase is the height of the motor development and is continuous throughout adulthood. Motor control and competence are achieved to the full. However, many children do not achieve this phase. They are inhibited by various factors, whether due to a lack of opportunity, equipment and facilities or even the individual's level of talent and physical condition.

In summary, the phases of motor development incorporate the total development of a child. The phases reflect reflexive, rudimentary, fundamental and finally specialized movement. Through various stages, determined by age and maturation, the child can achieve status in each phase. Each phase presents added abilities to create balanced motor development. It is only when children fail to produce or enhance these abilities, that concern is raised about their motor development. The following section provides insightful information on developmental delays.

2.5 MOTOR PROFICIENCY DELAYS

Motor proficiency disturbances only become evident during school age, when children face challenges in all their aspects, whether they experienced difficulties as infants or not. When these challenges become too great, avoidance and dislike for tasks become apparent. Maldonado-Duran *et al.* (2002), provide a clinical picture of motor problems manifested from infancy until middle childhood.

In accordance with the variables of motor development (see section 2.3.2), muscle tone is affected during infancy. Either low or high muscle tone is noted when the infant experiences difficulties performing movements. Children are often delayed in achieving rudimentary movements such as rolling or sitting.

Early childhood marks the changes in size, proportion and shape of the child (ages two to six). However, the most dramatic changes occur in the gross motor skills, the large body movements (Craig, 1996: 154-260). In comparison, the fine motor skills develop at a slower rate, which, according to Craig (1996: 154-260), is due to the immaturity of the child's central nervous system. However, a 2-year old child with motor delay may experience more difficulty in fine motor skills when chewing or picking up small objects. The child who still walks with assistance during this time may experience either hyper- or hypo-tonicity.

From the age of three and upwards, fundamental skills are required for effective movement production. With the obvious difference of each individual child in achieving development, there is still the possibility that motor delays can be identified. A lack of hand preference can be a factor of motor delay, and in some cases, ambidexterity is present. Fine motor skills appear to be the most identifiable and more studies have reviewed this subject (Coetzee, Pienaar and Aucamp, 2001, Smits-Engelsman, Niemeijer and Van Galen, 2001, Maldonado-Duran et al., 2002). Children seem to have high-energy expenditure when experiencing motor difficulties and tire quickly.

In summary, motor development follows a process of on-going change in a child, who adapts to this change according to his/her circumstances. Development occurs as a process, involving the functioning of neurological structures. An alternative way to describe motor development is to focus on how this movement performance changes over time. In such a description, changes appear to occur in four phases, distinguished by children when improving their motor proficiency in each new phase. When children have difficulty in achieving successful movement, they are suspected of having a developmental delay. This delay may be neurological or otherwise, a problem not yet determined. However, this problem can be described, whether using

observable behaviour or theoretical aspects to eventually find a way of treating it. The next section endeavours to provide some understanding of such a problem and shed more light on Developmental Coordination Disorder (DCD) itself.

2.6 DEVELOPMENTAL COORDINATION DISORDER (DCD)

Developmental Coordination Disorder (DCD) is a disorder characterized by motor impairment that interferes with the daily life activities of a child. The purpose of this section is to review the literature around the incidence of DCD, understanding the term DCD according to research, discussing the theories behind the concept of DCD and, finally, exploring its co-morbidity with other disorders.

2.6.1 Incidence of DCD

Current research indicates that 5-8% of all children between the ages of 6-12 experience DCD (Candler and Meeuwsen, 2002; Barnhart, Davenport, Epps and Nordquist, 2003) and that DCD occurs more frequently in boys than in girls (at a ratio of 2:1). Researchers all over the world have estimated the prevalence of DCD in their specific countries. In the USA, ten years ago, 10-19% of all school-aged children in the country displayed DCD symptoms. Tervo (2003) indicated that at least 8% of all Canadian pre-school children from birth to 6 years have developmental problems. Miller, Missiuna, Macnab, Malloy-Miller and Polatajko (2001) estimated the incidence of DCD in Canada to be 5-6% of elementary school children. That approximated 129 000 Canadian children (Miller *et al*., 2001) at the time. Australian researchers indicated in 1995 that 5-15% of primary school children have DCD (Sprinkle and Hammond, 1995). Further, in every classroom, 2-3 children indicated signs of DCD. In Sweden, Kadesjo and Gillberg (1999) estimated that 5% of all children display signs of DCD. Kadesjo and Gillberg (2001) indicated that ADHD was associated with half of the cases of children with DCD. This longitudinal study concluded that 22-year olds that had DCD in their childhood, still experienced motor-control problems, and 30% of them still met the criteria for DCD. They also mentioned that in the United Kingdom, 10% of the general population experience DCD, but with milder problems.

Pienaar (1995) obtained a rough estimate of the incidence of DCD in the North-West Province of South Africa to be 8.3%. Further studies in South Africa on the prevalence and incidence of DCD are still needed for the total population. It is possible, however, that much the same situation will exist in South Africa as elsewhere in the world.

In order to explore solutions for DCD one first has to understand what the disorder entails, which is not an easy matter as its manifestation is subtle and essentially to be found in behaviour rather than physical abnormality.

2.6.2 Understanding DCD

In spite of the apparent prevalence of DCD, it is not an easily comprehensible disorder such as cerebral palsy or even autism (Wright and Sugden, 1996). DCD reflects a specific problem with coordinative tasks despite any evidence of neurological, biochemical or physical abnormalities. However, it does incorporate many specific features and is not restricted to noticeable motor skills. It also affects the child academically and socially.

The recognition of DCD as a disorder suggests that it is associated with behaviour problems (Kadesjo and Gillberg, 1999). These problems correlate with cognitive and perceptual problems but it is not yet known whether DCD or perceptual problems are correlated with psychological disabilities. Concerning environmental demands and expectations, motor performance varies for each child.

Various behavioural problems in children with DCD were identified in Kadesjo and Gillberg's study on Swedish 7-year old children with DCD in 1999. They found that DCD children displayed introverted social skills, less self-confidence with respect to physical and social skills, feelings of inferiority, being less well-liked by peers and school adjustment difficulties (Kadesjo and Gillberg, 1999). With these findings, they concluded that 65% of children with DCD also have Attention-Deficit Hyperactivity Disorder (ADHD). This combination of DCD and ADHD is often referred to as Deficits in Attention, Motor control and Perception (DAMP).

According to Kadesjo and Gillberg (2001), neurodevelopment disorders such as DAMP, DCD and ADHD are common among school-aged children and the causes of these disorders can be found in hereditary, neuro-pathogenic and social factors. Some have suggested that motor coordination problems are due to physiological causes and some have insisted that they are the result of a developmental delay. With such suggestions, Willoughby and Polatajko (1995) insisted on treatment being essential for motor coordination remediation.

It is clear that DCD significantly affects a child's ability to function "normally" (Mandich, Buckolz and Polatajko, 2002). To function "normally" the child needs to achieve motor proficiency. This is where the DCD child fails. However, not all DCD children fail in the same area, so that individual children with DCD display different characteristics of the disorder. Attention must now be given to an indication of the different attributes within the DCD diagnosis.

2.6.3 Characteristics of DCD

As mentioned, DCD is considered a heterogeneous disorder as children display such a range of dysfunction. In addition, within the DCD group itself children differ from each other in their abilities to perform movement (Wright and Sugden, 1996). Mon-Williams, Wann and Pascal (1999) conducted a study with DCD children where the children displayed an inability to differentiate between vision and proprioception. The researchers related this inability to be a contributing factor to poor motor coordination (Mon-Williams *et al*., 1999). Coetzee *et al*. (2001) and Smits-Engelsman *et al.* (2001) have all found deficits in children's performance of fine motor skills. Visser (2003) reports that literature associates DCD with almost every motor and sensory problem imaginable and that abnormalities in postural control have been depicted.

Abnormalities in the execution of movements are also well documented. Geuze, Jongmans, Schoemaker and Smits-Engelsman (2001) found that children with DCD suffer from a lack of balance. They suggested that balance is a precondition for the development of a variety of other motor skills, such as handwriting, walking, throwing and catching (Geuze *et al*., 2001).

It has been suggested that DCD children have an increased reaction time compared to normally coordinated children (Raynor, 1998). Raynor conducted a study to examine the validity of this suggestion. Total reaction time, pre-motor time and motor time were analysed on a visual reaction task. She found that total visual reaction differed considerably in respect of coordination level (DCD or non-DCD) and age (6 years and 9 years). The study produced evidence that timing delays are increased in children with DCD.

Vision plays an important role in the control of voluntary movement by providing effective information to allow for necessary movement adjustments. It predominates over sensory feedback to guide the movement. Visual search, actively looking for information from the environment, enables children to determine what to do in a critical situation where time for decision-making is limited. According to Willoughby and Polatajko (1995), experimental studies suggest that lack of visual memory skills may be involved in poor motor performance in children with DCD. Decisions will be determined in a large part by the effectiveness of the visual search strategies used by the child. Lefebvre and Reid (1998) agreed that DCD children need more visual information than their non-DCD peers do.

Fine motor skills form an integral part of the child's life, as they are required in almost every daily task. Thus, it is essential for the child to learn such motor skills so that there can be an improvement in motor proficiency. Miller *et al*. (2001) identified handwriting as a highly common problem in referred children. Barnhart *et al*. (2003) indicate that often the first identifiable sign of DCD is difficulty with handwriting. They also mention problems with gripping and dressing (Barnhart *et al*., 2003). Tervo (2003) reported that children experiencing fine motor delays should be considered to have DCD.

The pathological mechanisms underlying DCD are largely unknown and the nature of motor coordination problems has been debated through various theories as reflected in the literature.

2.6.4 Theories on DCD

Many researchers have pointed to the effect of sensory processing in motor coordination. However, they seem to disagree on whether poor motor coordination is a result of a multi-sensory or a uni-sensory deficit. Willoughby and Polatajko (1995) compared these two theories. First, the multi-sensory theory can also be described as the sensory integration theory or the neuro-maturational theory. This theory is the most renowned theory, proposed by Ayers in 1972 (Willoughby and Polatajko, 1995). Sensory integration dysfunction demonstrates deficits in motor planning and unsuccessful movements (Willoughby and Polatajko, 1995) and concerns the inability to integrate information from various sensory origins (Candler and Meeuwsen, 2002). Motor dysfunction is detected based on late attainment of developmental milestones and abnormalities in muscle tone and reflexes. Treatment therefore, started by focusing on normalizing muscle tone (Hadders-Algra, 2000).

Secondly, the uni-sensory theory looks at the processing of information from one single sense. The vestibule, visual and proprioceptive systems were explored and all three found to contribute as a singular factor to the poor motor coordination of the child (Willoughby and Polatajko, 1995). Both theories, therefore, contribute to the understanding of poor motor coordination (DCD) and both theories can be useful in finding intervention methods.

To understand how coordinated voluntary movement is controlled, an approach called the dynamic systems theory was developed in 1980. This theory of motor control characterises the interaction between the child and the environment. The theory does not consider development in terms of unfolding patterns only, but also assumes the effect of the environment on the development of the child. This stresses the interrelationship between the individual, the environment and the task (Haywood and Getchell, 2001: 20-23). It states that the nervous system controls skilled movement, and forces certain muscles and joints to act co-operatively so that the task can be completed. The benefit of the dynamic systems theory is that the environment can be manipulated to alter motor development (Hadders-Algra, 2000). However, this theory pays little attention to the role of the CNS, which consequently may limit its validity.

Hadders-Algra (2000) described DCD as the result of some damage at cellular level. The theory, the Neuronal Group Selection Theory or the NGST, was developed in 1993 by Edelman and describes certain areas in the brain to be organised into networks. These networks or units of selection consist of strongly connected neurons, called neuronal groups. Development proceeds when the neurons are exposed to a multitude of experiences. After selection, behavioural changes become less varied. The NGST suggests that DCD children may be linked with a minor neurological dysfunction or MND (Hadders-Algra, 2000), which promotes uncoordinated behaviour. Hadders-Algra suggests that if the DCD child does not display signs of MND, clumsy behaviour should be mainly attributed to social disadvantage. However, if the child's problems are in fact linked with MND, inappropriate selection of behaviour results in variable motor behaviour such as DCD. These deficits in selection, according to the NGST, can be due to deficits in sensory integration, kinaesthetic and proprioceptive processing (Hadders-Algra, 2000).

Barnhart *et al*. (2003) also relate outward and observable disabilities of DCD to neuropathology. They suggest that children's problems result from impairments in proprioceptive systems, motor programming and timing, thereby supporting the NGST. They highlight the NGST as the theory proposes a more complex look at not only typical development, but also at dysfunction, specifically DCD (Barnhart *et al*., 2003).

DCD is a disorder that involves impairment in the development of motor coordination and interference with various activities. This feature is prominent in a variety of other disorders, some of which will be mentioned here. However, these disorders are sometimes found together with DCD and in many cases, a child may be diagnosed with a co-existing disorder together with DCD. Miller *et al*. (2001) in an attempt to clinically describe DCD, came across numerous children with multiple co-morbidities.

2.6.5 Co-morbidity of DCD

Research has shown that the most frequent disorders related to DCD (Miller *et al*., 2001) were learning disabilities (38.5%) and Attention Deficit Hyperactivity Disorder

(ADHD) (41.1%). Another disorder commonly linked with DCD, is Asperger's Syndrome (AS).

DCD is purely a motor coordination disorder, when the child has significant interference with academic endeavours and activities of everyday life (Kadesjo and Gillberg, 1999; Maldonado-Duran *et al*., 2002). However, many children with motor coordination difficulties also experience other problems. The most common are those linked to attention and concentration difficulties and even hyperactivity (ADHD). ADHD is a combination of developmental problems with important medical, educational and social implications. Research indicates that co-morbidity may exist between ADHD and DCD (Harvey and Reid, 2003). Scandinavian countries have developed a new term for those who display characteristics of both DCD and ADHD, namely Deficiency in Attention Motor control and Perception (DAMP), a condition that may have stronger validity in terms of common background factors and poorer academic outcomes (Kadesjo and Gillberg, 1999).

Thus, substantial evidence proves that problems in motor coordination and motor execution exist in children with ADHD (Kadesjo and Gillberg, 1999; Kadesjo and Gillberg, 2001; Blake and Anderson, 2002; Harvey and Reid, 2003). Of the 409 children with DCD involved in a study by Kadesjo and Gillberg (1999), 47% had ADHD symptoms. Severe ADHD was found in 19% of the DCD children. Of those who had severe DCD, 55% indicated symptoms of ADHD and 15% met the full criteria (Kadesjo and Gillberg, 1999). Harvey and Reid (2003) also suggested co-morbidity between ADHD and DCD. They recommend future research to describe the specific movement skills of children with ADHD. Only if the criteria are met for both disorders, can both diagnoses be given.

Learning disabilities (LD) are often associated with DCD (Hoehn and Baumeister, 1994; Miller *et al*., 2001). Children with LD often show poor motor coordination and they have difficulty predicting, "what comes next" (Godley in Barnhart *et al*., 2003). Godley (in Barnhart *et al*., 2003) related this problem to cerebellum and cerebrum dysfunction altering the learning process.

DCD is also associated with Asperger's Syndrome (AS) (Green, Baird, Barnett, Henderson, Huber and Henderson, 2002). Children with AS also often display symptoms of poor motor coordination and 50%-90% of AS children have definite problems in motor coordination (Attwood in Barnhart *et al*., 2003). Green *et al*. (2002) however, indicated that children with AS can be more impaired than children with DCD. Kadesjo and Gillberg (1999) also identified a relationship between DCD and AS. The study indicated that some DCD children displayed more symptoms of AS than those without DCD, especially those with moderate to severe DCD.

It must be pointed out, by the way of summary, that the prevalence of DCD is still of concern, although it has decreased over the past 10 years. The incidence of DCD in South Africa remains uncertain and future studies should endeavour to obtain statistical evidence. However, it is safe to say that the general population with DCD forms about 5%-6% of primary school children in the western world. Research has increased greatly on DCD and therefore more understanding of the disorder has been achieved.

DCD is associated with cognitive and behavioural problems resulting from the impairment of motor coordination. Children are affected in many different ways, and the various characteristics they display include problems with balance, vision, reaction time (timing) and fine motor skills such as handwriting. Nevertheless, other problems with the sensory, proprioceptive and motor systems are equally observed. This fact calls for further knowledge of what this disorder entails and theoretical knowledge can stimulate researchers' ideas on intervention. The various theories on DCD create a basis to which the variety of factors involved can be attributed. Multi- and unisensory theories attribute motor problems to a disorder of the senses, incorporating the most renowned theory, sensory integration. The dynamic systems theory tries to incorporate not only the brain but also the environment into factors involved in development. The Neuronal Group Selection Theory provides a framework for determining the nature of DCD and finds a balance between sensory integration and the dynamic systems theories. Co-morbidity studies have looked at the relationships between DCD and other developmental disorders. Some of these disorders are ADHD, LD and AS. There is therefore reason to believe that there are overlapping factors in the etiology of these disorders.

To establish the exact nature of deficiency in children with DCD is a complex task. The available knowledge on DCD points to its diversity, which implies a need to find integrated approaches to intervention and management of this variable disorder.

2.7 APPROACHES TO INTERVENTION IN DCD

Throughout the literature, researchers have mentioned the various approaches to intervention programmes for children experiencing DCD. Past research focused on the process-oriented approaches, or bottom-up approaches, that support the remediation of underlying deficits (Missiuna, Malloy-Miller and Mandich, 1997; Pless and Carlsson, 2000; Henderson and Henderson, 2002). These approaches involve the more traditional focus points and include sensory integration therapy, process-oriented methods and perceptual motor training. Sensory integration therapy will be discussed as an example of these approaches.

Current research has introduced two new problem-solving approaches to the remediation of children with DCD. These approaches have contributed greatly to the improvement of motor problems as noted in the literature (Hadders-Algra, 2000; Pless and Carlsson, 2000; Missiuna, 2001; Maldonado-Duran *et al*., 2002; Barnhart *et al*., 2003). They include (1) the cognitive approach and (2) the task-specific approach. First, sensory integration therapy as a means for intervention, is discussed.

2.7.1 Sensory Integration Intervention

Sensory Integration (SI) is defined as the neurological ability to obtain information through the senses and to process it for movement production (Hoehn and Baumeister, 1994; Maldonado-Duran *et al.,* 2002). SI therapy addresses the underlying difficulties and involves specific input for the child and the facilitation of the desired adapted response (Hoehn and Baumeister, 1994; Maldonado-Duran *et al*., 2002). According to Leemrijse, Meijer, Vermeer, Ader and Diemel (2000), SI is a non-cognitive, movement-based therapy to enhance the brain's capacity to perceive and organize sensory information to produce an appropriate response. Leemrijse *et*

al. (2000) studied the effectiveness of SI therapy, together with a psychomotor therapy (Le Bon Depart or LBD), for children with DCD. The six subjects received both treatments but at separate times. After each treatment, the subjects were tested to determine results of that specific treatment. Five (5) of the 6 subjects improved significantly on the M-ABC after the intervention of both SI and LBD, but after the LBD therapy only, the subjects improved more than after receiving only the SI therapy. Leemrijse *et al*. (2000) concluded that although the sample was small, improvement after LBD therapy was greater than after SI therapy. Although this was more a study to introduce LBD therapy, other reviews on SI therapy show it to be effective but not necessarily better than other treatments (Maldonado-Duran *et al*., 2002).

Pless and Carlsson (2000) studied the SI approach together with kinaesthetic training. They stated that with SI therapy, possible gains were indicated but no clear improvement was found (Pless and Carlsson, 2000). Henderson and Henderson (2002) argued that regardless of the content of the intervention, generalisation presents a major problem in treating children with DCD. Barnhart *et al*. (2003) suggest that although there may be some gains in motor development after SI therapy, these gains do not generalize to functional skills.

2.7.2 Cognitive Intervention

An intervention that does promote generalisation and transfer of skills is an intervention concerned with cognitive approaches. Various cognitive approaches have been identified over a number of years, each involving a problem-solving framework to skill acquisition (Missiuna *et al.,* 1997; Mandich *et. al*., 2001). The most recent approach was formed by Polatajko (Missiuna, 2001) and termed the Cognitive Orientation to daily Occupational Performance (CO-OP). The focus of this approach is the strategy used to increase functional performance. In terms of motor development, this approach emphasizes active problem solving through identifying goals, planning the movement, executing the movement and receiving feedback. The literature available identified the cognitive approach to be superior to the process-oriented approaches. In addition, Barnhart *et al*. (2003) stated that children

receiving treatment using a cognitive approach maintain motor skills longer and create better opportunities for generalisation.

2.7.3 Task-Specific Intervention

Task-specific intervention involves the direct teaching of a specific skill. Motor tasks are broken down into steps, with each step taught independently. Next, the entire task is performed. Pless and Carlsson (2000) describe this kind of instruction as the specific skills (task-specific) approach. Their study focused on which of the theoretical approaches to intervention is supported by evidence, utilizing a meta-analysis of 13 research studies, from 1970 to 1996. They found evidence to support the specific skills approach (task-specific) above the SI approach, for children who are older than 5 years.

The cognitive and the task-specific approaches focus less on the specific impairments contributing to decreased motor coordination, and more on the overall coordinated movement (Barnhart *et al*., 2003). Together with the cognitive approach, the task-specific approach to intervention provides repetition and practice of specific motor skills with the inclusion of spatial and motor learning sequences (Barnhart *et al*., 2003).

Interventions to improve the motor proficiency of DCD children are necessary. Limited research is available on the success of intervention programmes and even fewer research studies investigating water as a medium for intervention have been conducted. In view of the fact that the proposed study involves the medium of water, the following section will focus on water-based intervention programmes involving the cognitive and task-specific approaches to intervention.

2.7.4 Water-based intervention

The cognitive and task-specific approaches have been proven successful for intervention on motor development delays as they involve overall coordinated movements and not only focus on a specific impairment. This is ideal for children with DCD, as research has indicated that specific developmental deficits of DCD

children vary from child to child (Miller *et al*., 2001; Missiuna, 2001; Henderson and Henderson, 2002), due to the heterogeneous nature of the condition. However, these approaches have only been applied to programmes that were land-based. Thus, it is worthwhile to investigate whether a programme using water as an intervention medium, while incorporating the above-mentioned approaches, could be valuable to a child struggling with coordinated movement.

Performing movements in water other than on land, often involves movement patterns that require total body coordination, thus incorporating all major muscle groups concerned in the execution of motor skills. The child is constantly moving in an environment that offers resistance to any activity that is performed. The resistance of the water slows movement of the body. Certain motor skills are more easily performed in water, as it offers the support not attainable on land, such as when losing balance and then recovering quickly. The child is also able to feel the movements as they are carried out (Councilman, 1982: 171-180), enhancing proprioception.

Of course, the greatest factor in dealing with children is that they need to perceive their actions as being enjoyable, fun and playful (Nearing, Johansen and Vevea, 1995). Therefore, having an alternative method of teaching motor skills, such as using various water activities in an after-school swimming programme for example, adds excitement and variety, reducing boredom and facilitating motor skill development. Skinner and Piek (2001) indicated that DCD children do tend to suffer from anxiety due to their inability to perform movements correctly and therefore ushering in feelings of shyness and unhappiness. When a child perceives something as being fun, however, anxiety can be reduced. With a water activities programme, a safe, secure and fun environment is provided for children (Langendorfer, 1990; Langendorfer and Bruya, 1995; Braun, 1997).

Braun (1997) adopted a child-centred approach to explore the possibility of a water activities programme as an intervention method for children with DCD. It is the only study that could be found implementing a water-based intervention programme for children with DCD. The study only used a small sample of seven children as test

subjects. However, interesting results were obtained. Braun concluded that an eight-week water activities programme definitely improved the motor proficiency of children with DCD. The effect was so dramatic that six of the children with DCD at the start of the study demonstrated motor proficiency adequate for their age after the programme. Positive changes were observed in other areas as well, such as general behaviour, social interactions and emotional development (Braun, 1997). The study was the first of its kind undertaken in South Africa and the implications of the results provided a new outlook on intervention using water that is inexpensive to administer.

Children who excel in swimming are not the only ones who can benefit from such water activities. Councilman (1982: 171-180) suggested that all children have the natural ability to learn to swim or to play in water. When children participate in a water activities programme, they are able to swim and take part amongst their peers. Using water as a medium in which to have fun and still develop motor skills can bring forth that anticipated effect of self-accomplishment in the child. It is also believed that skills learned in the water, facilitate transfer to similar activities on land (Councilman, 1982: 171-180).

To sum up, every approach to intervention in DCD is valued as it tries to improve motor proficiency in children. The question is just to find the right approach that suits the individual child and his/her needs. The SI approach to intervention was proven successful but could not be rated above any other approach. However, the approaches focusing on the immediate problem of motor coordination, providing the child with opportunities of repetition and practice are recommended above SI therapy. This leads to the adoption of a new and innovative approach, focusing on the problem of poor motor coordination or DCD, and includes using water activities and swimming as a fun alternative to land interventions.

In order to establish full appreciation of the problem of DCD, and recognising the need to identify the children to be considered for a suitable intervention programme, necessitates a discussion of assessment measures. Such measures do not only provide the researcher with a means to identify children with DCD but can also be

used for research purposes to establish effects after intervention. The two most popular standardised tests are referred to next.

2.8 ASSESSMENT MEASURES FOR DCD

The use of multiple standardized assessments (Miller *et al*, 2001) is common and may provide a more complete index of children's physical health and motor skill development. The identification of children with DCD requires a valid and reliable source of identification (Crawford, Wilson and Dewey, 2001). Failing to identify DCD can lead to further devastation in the DCD child's life. Thus, it is important to determine which measures can provide the researcher with consistent results. The following standardized assessments act as examples of measures that can be useful for the evaluation of children with suspected disabilities.

2.8.1 Movement Assessment Battery for Children (M-ABC)

The most frequently used test outside the USA is the Movement Assessment Battery for Children (M-ABC), developed by Sugden and Henderson in 1992 (Henderson and Henderson, 2002). The M-ABC identifies and evaluates the movement problems that can determine a child's participation and social adjustment at school and can assist in the planning of programmes for remediation and management. This unique assessment battery identifies and evaluates movement problems that determine a child's social integration at school. The M-ABC Checklist provides classroom assessment of movement difficulties, screening for "at risk" children and systematic monitoring of treatment programmes. It provides a comprehensive assessment for those identified as "at risk", yielding both normative and qualitative measures of movement competence, manual dexterity, ball skills and static and dynamic balance. The age range is 4 to 12 years with individual administration taking between 20 to 30 minutes. The purpose of the test is to provide screening, assessment and management of movement problems.

2.8.2 The Bruininks-Oseretsky Test of Motor Proficiency (BOTMP)

The second available test to assess motor proficiency is that of the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP). Accurate assessment of gross and fine motor skills is essential for the planning of individualised remedial programmes. The BOTMP was therefore designed to address the problem of accurately assessing and subsequently helping children with motor coordination difficulties.

This test has been described as the most outstanding instrument of its kind and one that fills a clinical void (Levine, 2002). The BOTMP is often considered as a necessary part of diagnostic testing and is useful in assessing gross and fine motor skills, developing and evaluating motor training programmes and screening for special purposes (Levine, 2002). The BOTMP is an individually administered test that assesses the motor functioning of children from 4½ to 14½ years of age (Bruininks, 1978: 11) suspected of having DCD. The BOTMP is perceived to have good psychometric properties and few alternative tests exist for the school age child (Wilson, Kaplan, Crawford and Dewey, 2000). The test was developed to provide clinicians and researchers with useful information to assist them in assessing the motor skills of individual students, in developing and evaluating motor training programmes and to assess serious motor dysfunction and developmental handicaps in children. Results of the BOTMP can be useful to educators, clinicians and researchers in evaluating children for a variety of purposes (Bruininks, 1978: 11).

Recommended uses are as follows:

- Evaluating the relationship between motor development and academic performance
- Assessing gross and fine motor skills
- Developing and evaluating motor training programmes
- Screening for special purposes

- Exploring aspects of motor development, such as the transfer of motor training to other areas of motor, social and academic learning.

The BOTMP consists of 46 separate items – comprising eight subtests (see Chapter 3). This provides a comprehensive index of motor proficiency as well as separate measures of both gross motor and fine motor skills. Examiners need not have special training but must become thoroughly familiar with the directions for administering the test and practise giving it in simulated situations before actual administration (Bruininks, 1978: 11).

As one of the most popular measures in North America (Crawford *et al*., 2001), the BOTMP was utilized in this study. Although the validity and reliability of the test have been questioned, the test enjoys great popularity still and is the longest running test used in North America. Due to the BOTMP's ability to measure skills that are important for children's development, it has gained wide clinical and educational acceptance (Wilson *et al.,* 2000). Conversely, the M-ABC test is an alternative test to the BOTMP (Crawford *et al*., 2001).

An investigation of both these tests concluded that DCD is confirmed by both these tests (Crawford *et al*., 2001). The study was conducted adequately, but the sample consisted only of Caucasian subjects. None of the subjects had been referred due to motor coordination problems, but for learning and attention problems. Nonetheless, the results indicated low levels of agreement in identifying DCD, between the BOTMP and the M-ABC.

Crawford *et al*. (2001) concluded that standardized tests may be limited in their identifying of DCD as the BOTMP may under-identify children and the M-ABC may penalize children with attention problems. Miller *et al*. (2001) recommended that this problem could be eliminated when using multiple standardised tests to assess children. The latter recommendation is not always possible from a practical or viable time point of view when conducting research studies.

2.9 SUMMARY

This chapter has presented the reader with a basic description of motor development. Motor development brings about change in the movement capabilities of a child in response to the ever-changing environment. As a process, motor development is based on the dynamic systems theory, involving underlying mechanisms such as the nervous system. Motor development as a product occurs in phases, in which biological factors and the environment in which children find themselves, play a significant role in ensuring progress. Gallahue, an avant-garde specialist in motor development, explains the phases by means of a model. Many children seem to sway from the norm and experience delay in their own particular development.

DCD is a disorder of impairment in motor coordination, thereby causing the child not to demonstrate motor proficiency. The problem occurs worldwide and is estimated to affect 5-6% of children living in the westernised world. South Africa in particular, still requires an accurate figure on the prevalence of the condition, especially with its diverse society. Research has focused on understanding DCD and some studies have brought us closer to determining the nature of the problem. Characteristics of DCD vary and each child presents his own limitations to movement. Theories of sensory integration, dynamic systems and neuronal grouping (NGST), have all contributed to more knowledge on DCD. However, the NGST seems to be the most logical in explanation of DCD.

Although DCD is described as a behavioural disorder, other neurological and pervasive disorders have been associated with DCD. These include ADHD, learning disability disorder and Asperger's Syndrome. More approaches to treatment methods can be explored, as research gets closer to determining the exact nature of DCD. Past approaches, including sensory integration therapy, have not been able to significantly improve the child's motor proficiency. However, new approaches involving cognitive and task orientation processes use problem-solving and systematic facilitation to produce skill acquisition.

This study bases its approach on these methods and aims to use an alternative medium, namely water, in its intervention, presenting an alternative way of promoting motor proficiency. It is assumed that by using water activities and swimming skills, the child is able to learn and apply typical motor skills, but in a different environment. Finally, identifying DCD rests with the two most popular tests, the M-ABC and the BOTMP. Although there is some inconsistency between the two, each test is able to perform its function when assessing motor proficiency.

CHAPTER THREE

METHODS AND PROCEDURES

3.1 INTRODUCTION

The procedures necessary to determine the effect of a water-based programme on the motor proficiency of children with DCD are explained in this chapter. The particular research design used as well as the selection of subjects are detailed together with an explanation of the composition of the control and experimental groups. A description of the measuring instrument used to determine motor proficiency is also given along with insight into the intervention programme. Furthermore, the method used to train testers is detailed, followed by a description of the analysis of results. Due to the involvement of children in the study, relevant ethical issues are also considered.

3.2 RESEARCH DESIGN

The study followed a quasi-experimental design. Two groups were involved, one that was influenced by the researcher through an intervention programme (the experimental group), and one that followed normal daily procedures and did not participate in the intervention (the control group). Both groups were tested using a pre-test post-test method implying that measurements of motor proficiency for both groups were obtained before and after the intervention programme.

Different methods of selection of subjects into the two sets of groups (experimental and control) were used. Two schools agreed to participate in the study. The first school (School A) included children who had all been diagnosed with poor motor proficiency. Random selection was used in this case to populate the experimental and control groups respectively. The second school (School B) included children

both with poor and with what is considered as “normal” motor proficiency. In this case, non-random selection was used. Children from School B, who scored poorly on the measuring instrument, thereby indicating poor motor proficiency, were selected to receive the intervention. This was done to simulate the experimental group from School A more closely. However, the consequence of the selection procedure used in School B resulted in the control groups being composed of both DCD and non-DCD children. The control group, although not equivalent to the experimental group in respect of motor proficiency, was nevertheless considered necessary to control for maturation over the eight-week period of study.

3.3 STUDY DESIGN

The District Manager in the Department of Education of the Eastern Cape, South Africa, granted permission to conduct the study in the two schools selected for this purpose. See Appendix A for a copy of the letter requesting permission from the Provincial Education Department. The Human Ethics Committee of the University of Port Elizabeth accepted the proposal and presented the researcher with guidelines and procedures to follow during the study. The researcher subsequently approached the principals of two schools to participate in the study. See Appendix B for a copy of the letter sent to the principals.

The two schools (School A and School B) that participated in this research project were approached separately and at separate periods in time. Both schools included children from different backgrounds in South Africa. The children from School A were formally diagnosed with DCD by the physical and occupational therapists at the school. School B included children who were not formally diagnosed with DCD. However, the children that were identified displayed signs of DCD, as indicated by their respective teachers.

Considering the fact that only relatively small numbers of children could effectively be dealt with during the intended intervention programme, and that two schools were used to source the relevant subjects for the study, two separate sets of testing and

intervention sessions were required. A control and an experimental group were identified for each school. The relevant results of these groups were treated separately and combined thereafter for the official analysis of results (refer to Chapter 4).

The researcher assigned the subjects to the experimental and control groups after Test 1 (the pre-test). From School A an experimental (EXP A) and control (CON A) group were selected. From School B an experimental (EXP B) and control (CON B) group were selected. Table 1 outlines the study design.

TABLE 1: STUDY DESIGN

GROUPS	TEST 1	INTERVENTION		TEST 2	RETENTION PERIOD	TEST 3
		APPLIED	PERIOD			
EXPERIMENTAL						
EXP A	Yes	Yes	8 weeks	Yes	-	No
EXP B	Yes	Yes	8 weeks	Yes	4 weeks	Yes
CONTROL						
CON A	Yes	No	-	Yes	-	No
CON B	Yes	No	-	Yes	4 weeks	Yes

A = School A

B = School B

The intervention programme, a water-based activities programme, involved the participation of both experimental groups and lasted for eight weeks of two lessons per week, for 30 minutes per lesson. The control groups carried on with normal daily activities and did not participate in the intervention programme. The intervention programme took place after school, based on the agreement with the particular school. After the intervention programme, all the subjects, including the control groups who did not participate in the intervention programme, were subjected to Test 2. The children then carried on with normal activities for one month (4 weeks), to allow for retention. A third test session (Test 3) was conducted with the children from School B at the end of the four-week period (one month) to assess the retention of motor proficiency.

3.4 SUBJECTS

Thirty-one (31) children participated in the study. The children were from around the city of Port Elizabeth, in the Eastern Province of South Africa. Children between the ages of 6 to 12, who displayed signs of poor motor proficiency, were included. A detailed description of the groups in each school follows.

3.4.1 School A

School A identified sixteen children originally. Two children did not participate. The fourteen subjects that participated were diagnosed with Developmental Coordination Disorder (DCD) according to physical and occupational therapists at the school. The BOTMP was used to test the fourteen children. One child, who did not qualify for DCD after Test 1's results on the BOTMP, did however participate through random selection in the control group. Table 2 gives a summary of the composition of the two groups in School A.

TABLE 2: COMPOSITION OF THE EXPERIMENTAL AND CONTROL GROUPS FROM SCHOOL A

SUBJ	SCHOOL	GROUP	AGE	GENDER	BOTMP SCORE	SUBJ	SCHOOL	GROUP	AGE	GENDER	BOTMP SCORE
1	A	EXP	9	M	114	13	A	CON	10	M	68
2	A	EXP	8	M	123	9	A	CON	8	M	112
3	A	EXP	8	F	48	11	A	CON	7	M	102
4	A	EXP	8	F	90	12	A	CON	8	F	61
5	A	EXP	8	M	95	10	A	CON	9	M	99
6	A	EXP	10	M	65	8	A	CON	12	M	103
7	A	EXP	10	F	76	14	A	CON	10	F	97

Each child was randomly selected into the experimental and control groups. From School A, thirteen children presented with DCD on the BOTMP, while one child did not. After random selection, the EXP group consisted of seven children with DCD and the CON group consisted of six children with DCD and one without. Of the fourteen subjects, seven were in the experimental group, and seven were in the control group. Nine of the fourteen children were boys. The 14 children participating

in this study from School A also underwent physiotherapy and occupational therapy before, during and after the implementation of the water-based programme as part of the curriculum of School A.

3.4.2 School B

School B identified 24 children to participate in the study. None of the 24 subjects had been formally diagnosed with DCD. However, teachers identified all the subjects who were suspected of having poor motor proficiency. Refer to Table 3 for a detailed description of the experimental and control groups.

TABLE 3: COMPOSITION OF THE EXPERIMENTAL AND CONTROL GROUPS FROM SCHOOL B

SUBJ	SCHOOL	GROUP	AGE	GENDER	BOTMP SCORE	SUBJ	SCHOOL	GROUP	AGE	GENDER	BOTMP SCORE
15	B	EXP	12	M	103	23	B	CON	11	M	133
16	B	EXP	10	M	120	26	B	CON	9	M	145
17	B	EXP	10	M	117	24	B	CON	9	M	165
18	B	EXP	9	F	122	27	B	CON	9	F	138
19	B	EXP	10	M	97	28	B	CON	10	M	159
20	B	EXP	9	M	120	29	B	CON	9	F	131
21	B	EXP	8	F	129	25	B	CON	8	F	155
22	B	EXP	7	F	124	31	B	CON	7	F	153
						30	B	CON	8	F	137

Three (3) children withdrew before any testing commenced. Four (4) parents did not give permission for their child to participate. Thus altogether, 17 children from school B participated in the study. These 17 children were tested on the BOTMP of which five could be classified with DCD according to this measuring tool. The latter, together with three other children who had low scores, were selected for the experimental group. The nine remaining children formed the CON group and according to their BOTMP Test 1 scores, did not present with DCD. None of the children from School B underwent physiotherapy or occupational therapy during the study.

The children from schools A and B (n=31) were tested again on the BOTMP after the 8-week intervention programme (Test 2). Four weeks after Test 2, the control and experimental groups of school B only, underwent a third test, a post-retention test (Test 3).

3.5 MEASURING INSTRUMENT

The BOTMP assesses motor proficiency of children between the ages of 4½ to 14½. This test was selected because it is an internationally recognized test to assess and identify children with DCD (Wilson *et al.,* 2000) and determines motor proficiency. Secondly, the BOTMP is also one of the most popular motor proficiency tests currently used when assessing children. Thirdly, the BOTMP testing procedure provided a fun atmosphere for each child being tested. Fourthly, the BOTMP is easily obtainable and is a non-complicated test to administer.

The BOTMP was administered within one week before and within one week after the intervention programme on both experimental and control groups. Four (4) weeks after the intervention programme, it was used again to test retention in the 17 subjects from School B. The scoring was done according to standardized procedures described in the BOTMP manual (Bruininks, 1978: 142-147).

3.5.1 Description

The BOTMP-Long Form has eight subtests with 46 separate items. BOTMP will be used as an abbreviation in the rest of the text, but it will imply the Long-Form. It was developed to provide educators, clinicians and researchers with information to assist them in assessing motor proficiency of children and subsequently developing and evaluating the effect of motor training programmes (Bruininks, 1978: 11). The complete battery of the BOTMP test yields three estimates of motor proficiency: Gross Motor Composite, Fine Motor Composite, and Battery Composite. The Gross Motor Composite is an index of the ability to use the large muscles effectively and summarizes subtests 1-4. The Fine Motor Composite is an index of the ability to use the small muscles (arm and hand) effectively and summarizes subtests 6-8. Subtest 5 evaluates both gross and fine motor skills (upper limb coordination). The Battery

Composite summarizes the performance of all the subtests and is an index of overall motor proficiency. Each of the eight subtests is designed to assess important aspects of movement development. The normative data provided for the test are based on the results of carefully selected subjects. The first item analysis edition was given to 75 children to determine the clarity and adequacy of scoring standards (Bruininks, 1978: 18). A second analysis programme was conducted on 250 children with adequate socio-economic and ethnic representation, coming from the area of Minneapolis (Bruininks, 1978: 18). The information includes standard scores for each age group, percentile ranks and stanines. Age equivalents are also provided for each subtest. Table 4 explains each subtest, what it measures, the number of items in each subtest, the task to be performed, the scoring procedures and the equipment used.

3.5.2 Validity

The validity of the BOTMP is based on its ability to assess motor proficiency. The evidence that the researchers of the test considered was (1) the relationship of test content, (2) the relevant statistical properties, and (3) the functioning of the test.

The current BOTMP is based in part on the Oseretsky Tests of Motor Proficiency and on surveys from relevant studies (Bruininks, 1978: 28). A wide selection of researchers was identified to determine validity for the test. These researchers focused on determining the statistical relationship of the test scores to the chronological age of the child being tested. This relationship was found to have correlation coefficient values of between 0.57 and 0.86 with a median of 0.78 (Bruininks, 1978: 29), indicating positive linear relationships. Internal consistency between the subtests was determined and correlation coefficient values of between 0.56 and 0.87 were found (Bruininks, 1978: 29), also indicating positive relationships. Factor analyses were performed for each of the 46 items and in each item the point scores were used for the analyses. The factor analyses provided the support for the grouping of items into subtests (Bruininks, 1978: 31).

TABLE 4: THE BRUININKS-OSERETSKY TEST OF MOTOR PROFICIENCY

Subtests	Title	Measure	Items	Task	Scoring	Equipment
Pre-test	Arm and Leg Preference	Arm and Leg Preference	2	Throw Tennis ball Kick Tennis ball	Circle preference Circle preference	Tennis ball Tennis ball
1	Running Speed and Agility	Speed	1	Shuttle run	Record time	Tape measure Masking tape Block Stopwatch
2	Balance	Balance skills	8	Pref leg on floor Pref leg on beam Pref leg, eyes closed Walk on line Walk on beam Walk heel-to-toe on line Walk heel-to-toe on beam Step over stick on beam	Record time Record time Record time Record steps Record steps Number of correct steps Number of correct steps Pass or Fail	Masking tape Balance beam Response stick Stopwatch Target
3	Bilateral Coordination	Coordinate movements (both sides of body)	8	Tap feet alt, circle fingers Tap foot and finger-same side Tap foot and finger-opp side Jump in place, same side Jump in place, opp side Jump up and clap hands Jump up and touch heels Draw lines and crosses simultaneously	Pass or Fail Pass or Fail Pass or Fail Pass or Fail Pass or Fail Number of claps Pass or Fail Number of pairs	St Booklet 2 red pencils 2 chairs Table Clipboard Stopwatch
4	Strength	Arm and shoulder strength Abdominal strength Leg strength	3	Standing broad jump Sit-ups Knee push ups	Distance of jump Number of sit-ups in 20sec Number of push-ups in 20sec	Tape measure Masking tape Speed stick Gym mat

TABLE 4: THE BRUININKS-OSERETSKY TEST OF MOTOR PROFICIENCY (Continued)

Subtests	Title	Measure	Items	Task	Scoring	Equipment
5	Upper Limb Coordination	Gross and Fine Motor Skills	9	Bounce and catch ball	Number of catches	Standing mat
				(both hands and pref hand)	Number of catches	Masking tape
				Catch tossed ball	Number of catches	Tape measure
				(both hands and pref hand)	Number of catches	Target
				Throw ball at target (pref hand)	Number:correct throws	Tennis ball
				Touch swing ball with finger	Number of trials	Ball with string
				Touch nose with finger		Stopwatch
				(eyes closed)	Pass or Fail	2 chairs
				Touch thumb to fingertips	Pass or Fail	Table
				(eyes closed)		
				Pivot thumb and index finger	Pass or Fail	
Subtests	**Title**	**Measure**	**Items**	**Task**	**Scoring**	**Equipment**
6	Response Speed	Ability to respond quickly	1	Use thumb to stop stick	Obtain the median	Response Stick
		to a moving stimulus		as it drops	of 7 trials	2 chairs
7	Visual-Motor Control	Ability to integrate	8	Cut out circle with pref hand	Number of errors	St Booklet
		visual responses with		Draw line through crooked path	Number of errors	Scissors
		motor responses		Draw line through straight path	Number of errors	2 red pencils
				Draw line through curved path	Number of errors	2 black pencils
				Copy circle	Accuracy	Table
				Copy triangle	Accuracy	2 chairs
				Copy diamond	Accuracy	Clipboard
				Copy overlapping pencils	Accuracy	
8	Upper-limb Speed and	Hand and finger dexterity	8	Place pennies in box		Same as Subt 7
	Dexterity	Hand speed		(pref hands and both hands)	Number of pennies	Pegboard
		Arm Speed		Sort cards	Number of cards	24 pennies
				String Beads	Number of beads	50 shape cards
				Displace pegs	Number of pegs	20 wooden beads
				Draw Vertical lines, Dots	Number correct	20 wooden pegs

3.5.3 Reliability

Test reliability refers to the precision and consistency of the test measurement. The BOTMP is a commonly used standardised test, especially to assess children suspected of DCD (Wilson *et al.*, 2000). Bruininks (1978: 34) warns users that every test contains some degree of error, whereby chance factors play a role. However, two types of statistics were used to report on the reliability of the BOTMP. They are the reliability coefficient and the standard error of measurement (Bruininks, 1978: 34). The reliability coefficient compares the trustworthiness of different tests (subtests) and the standard error of measurement interprets the scores obtained by individuals. The reliability coefficient values indicated for the Gross and Fine Motor Composites of 63 children in Grade 2 were 0.77 and 0.88 respectively. For 63 children in Grade 6, the reliability coefficient values for the Gross and Fine Motor Composites were 0.85 and 0.68 respectively. For the Battery Composite, the relevant values obtained were 0.89 for Grade 2 and 0.86 for Grade 6. The standard error of measurement values indicated 4 or 5 for the composite scores.

3.6 INTERVENTION PROGRAMME

Water therapy is used effectively for physical and mental rehabilitation, fitness, relaxation, perceptual-motor remediation, self-concept enhancement, fun and competition (Langendorfer and Bruya, 1995). Exercises that are traditionally performed on land could also be done in the water, with the effects of gravity being minimised. The child can accomplish them with greater ease than when on land. Therefore, a water-based intervention method could be meaningful to a child with DCD.

3.6.1 Rationale

A water activities programme is an innovative alternative intervention method. The main rationale for using water as the intervention medium is the obvious environmental change for the child. No other medium can provide this change in

environment so effectively. This change gives the child new opportunities to be successful and to overcome obstacles in a different way.

A water activities programme provides the child with enjoyable and worthwhile participation (Harrison, 1989: 9; Langendorfer and Bruya, 1995). Furthermore, water activities provide opportunities for the social, psychological and physical development of the child. The support that water provides reduces the pressure of body weight, thereby minimizing the effect of weak muscles and lack of balance on the child's motor proficiency (Councilman, 1982: 177-182). Harrison (1989: 10-11) lists psychological, physical and sociological benefits of participating in a water activities programme. The psychological values include improvement in self-image and creating opportunities to experience or risk a challenge. Physical values are numerous, specifically improving weak muscles, developing coordination and perceptual-motor ability. Sociologically, the water can provide the child with the opportunity to participate together with his/her peers, offering cooperation with others and the opportunity to be involved in competition.

3.6.2 Content

The aim of the intervention programme was to improve children's motor proficiency. The 16 different lessons incorporated variables of motor proficiency through the means of various swimming drills and water activities. The programme was conducted in a heated pool (26-28 degrees) with the researcher as the instructor. The lessons were taught in a group situation but individual attention was provided as needed. Sixteen (16) lessons were conducted and each lesson addressed specific variables. A typical lesson included warm-up or introductory activities, basic swimming skills, activities based on the variables addressed and play time. Table 5 indicates the lesson number and the purpose for that specific lesson (see Appendix E for a detailed description of each lesson) and Table 6 provides examples of the types of activities that were incorporated in the water-based activities programme.

TABLE 5: THE PHYSICAL AND MOTOR PROFICIENCY FOCUS OF LESSONS IN THE WATER-BASED ACTIVITIES PROGRAMME

LESSONS	PURPOSE
1, 2	Introduction
3, 4	Balance and coordination
5	Balance and strength
6	Strength and agility
7	Coordination and strength
8	Visual-motor control, coordination, strength
9, 10	Coordination, visual-motor control, rhythm
11, 12	Strength, coordination, rhythm
13, 14	Basic swimming drills
15, 16	All variables (games days)

TABLE 6: TYPES OF WATER ACTIVITIES AND THEIR RELEVANT PURPOSES

TYPE OF ACTIVITY	VARIABLE
Kicking while sitting on the edge	Warm up/ introductory
Blowing bubbles	Warm up/ introductory
Jumping up and down in the water	Warm up/ introductory
Running in the water	Warm up/ introductory
Bunny hops	Warm up/ introductory
Swimming in circles	Warm up/ introductory
Kick with board (front and back)	Strength, timing, balance
Streamline positioning on board	Basic swimming skill (posture)
Using hands and arms simultaneously and alternatively	Coordination
Swimming froggy style (breaststroke)	Coordination
Swimming with pool noodle or kickboard	Balance
Floating on boards, pool noodles	Balance, coordination
Catching and throwing balls, pushing balls with chin, swim through hula-hoops	Eye-hand coordination, strength, agility
Kicking with a rhythm	Timing (rhythm)
Swimming under water	Strength, agility
Swim and throw balls in baskets around pool	Visual-motor control, coordination,
Catch objects while jumping into pool	Visual-motor control, eye-hand coordination
Games	Incorporating all variables

3.6.3 Duration

The intervention programme was an eight-week programme consisting of water activities. The eight-week programme, with two lessons per week, catered for 16 lessons in the water in total. Each lesson was 30 minutes long.

3.6.4 Equipment

Some of the equipment used consisted of recognized swimming aids (kickboards, pool noodles, flippers, goggles) by Learn to Swim, South Africa. Other aids included plastic balls, hula-hoops and sinking rings. A brief description of each is provided.

3.6.4.1 Kickboards

Kickboards are buoyant flat boards usually made of foam materials, which the child uses to rest his/her arms while performing kick drills (Rhodes, 1993: 5). Kickboards could aid the child with stability and security in the water, while the child was actively kicking or practising drills. The kickboards also offered the child the opportunity to get used to lying in a horizontal position, facilitating his/her ability to balance.

3.6.4.2 Pool Noodles

Pool noodles are also made from foam materials and are long thin objects. Usages of pool noodles include practising balance, floating and entertainment for the child. The researcher used pool noodles as a balance tool for the children to sit on and project their selves through the water using their arms and legs in a coordinated fashion. The noodles were also used to jump over and under into the water. As a floatation device, a noodle provides the child with head and neck control and helps compensate for uneven weight distribution.

3.6.4.3 Flippers

Flippers aid the child with kicking and strengthening of the legs, helping the child to kick in the correct fashion and become more agile in the water. With the aid of flippers, the child can “fly” through the water and increase his/her ability to coordinate the lower limbs with the upper limbs.

3.6.4.4 Plastic balls

The lightweight balls were used to catch, kick and throw in the water, during different games and exercises. For example, the child would jump and catch the ball in the air before landing in the water. To aid eye-hand coordination as well as visual motor skills, the child would swim around the pool throwing the ball into baskets on the side. In addition, games of adapted water polo were played after each session as part of playtime.

3.6.4.5 Hula-Hoops

These plastic circular objects were ideal to dive through, swim underneath and jump through from the wall. They also aided in strength development, as the children were required to jump in ankle-deep water in and out of the hula-hoop.

3.6.4.6 Sinking Rings

These colourful rings are sinkable and ideal for timid students for retrieval activities in or under the water (Rhodes, 1993: 5). These rings aid in improving visual-motor control by the child moving through the water towards the object and retrieving it.

3.7 TRAINING OF TESTERS

For Test 1, Test 2 and Test 3, the researcher required a group of eight testers at a time, to assist with the testing procedures. Each of the testers was assigned a subtest to test the individual child.

The researcher approached the Department of Human Movement Science, at the University of Port Elizabeth, to assist in this matter. Third-year Human Movement Science students were selected to assist in the testing. All of these students underwent a briefing about the tests and were required to attend training sessions that included a practice round when a mock test was conducted.

The training sessions consisted of a background to the study and a detailed description of the BOTMP. Each of the testers was given a detailed description of their specific subtest and they had to conduct each item of the subtest with the researcher before the practical session started. The practical session was a mock test of the actual situation and one subject, who was not part of the actual study, agreed to participate in the mock testing session. During this occasion, all the testers were evaluated on their ability to conduct the test, according to the instructions given by the BOTMP Manual.

3.8 STATISTICAL ANALYSIS

The experimental and control groups' data from each school were combined for the final analysis of the results. Each group obtained a mean score for every variable on the BOTMP to determine motor proficiency before, immediately after and one month after the intervention programme. The groups were described in Test 1, Test 2 and Test 3 using mean percentages with their respective standard deviations (S.D.). The data obtained in these three separate tests were analysed by means of the statistical procedure, the analysis of co-variance (ANCOVA). The t-test was applied to evaluate the mean differences between the experimental and control groups. Statistical significance was determined and a $p < 0.05$ was set. Practical significance was determined by means of Cohen's d and a criterion value of $d > 0.20$ was set. Correlation values examined relationships between the variables, using the Pearson correlation coefficient (r).

3.9 ETHICAL CONSIDERATIONS

The Society for Research in Child Development has set a list of principles to adhere to when conducting research that involves children. Following is a list of these principles in the format of a description of the researcher's undertaking to adhere to these principles.

- Each parent or guardian of potential subjects received a letter of consent in which the purpose of the research and details pertaining to the testing involved were described (see Appendix C). The letter provided the opportunity for parents or guardian to give their permission for their child to participate in the research. Consent to participate in the study was also sought from the relevant children who's parents/guardians had given permission for their participation (See Appendix D).

- Verbal consent from those interacting with the child everyday, such as schoolteachers, occupation therapists and physiotherapists, was also sought.

- The researcher defined the responsibilities of all parties involved in the study such as: the control group who carried on with daily activities; the experimental group whose parents had to commit to bringing their children to the intervention programme for its duration; and the testers to whom the BOTMP was clearly explained and practically evaluated.

- The researcher avoided unnecessary risks during the participants' involvement in the study by ensuring safety around the pool.

- All interviews with parents and teachers, as well as results obtained from the testing, were handled with strict confidentiality.

- The researcher undertook to be cautious when reporting, making statements or giving advice. Results were reported as accurately as possible and the researcher respected the confidentiality and privacy of the children and their families.

Once all these procedural and preparatory matters had been dealt with, the researcher was able to proceed with the implementation of the programme.

CHAPTER FOUR

RESULTS

4.1 INTRODUCTION

This chapter reports on the results before and after the eight-week water activities programme, in fulfilment of the objectives set for this study. The presence or absence of DCD in the children was determined by calculating their scores based on the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP). Three variables of motor proficiency were identified and a total composite score for motor proficiency (BAT) was determined. The three individual variables were: Gross Motor Skills (GMS), Upper Limb Coordination (ULC) and Fine Motor Skills (FMS).

In further testing, the effect of the water-based activities programme on improving motor proficiency was confirmed if the null-hypothesis was rejected. Motor proficiency scores were obtained in Test 1 (pre-test), Test 2 (post-test) and Test 3 (retention test), for both experimental and control groups, using the BOTMP variables. From these scores, comparisons between the experimental and control groups were drawn for each of the three tests respectively.

4.2 MOTOR PROFICIENCY ON THE BASIS OF TEST 1 AND TEST 2

At the start of the study, both the experimental and control groups were tested on the BOTMP to establish their initial motor proficiency scores to be used for comparison after the intervention, when the test was repeated. All the subjects obtained a set of scores pertaining to the variables on the BOTMP: GMS (gross motor skills), ULC (upper limb coordination), FMS (fine motor skills) and BAT (overall motor proficiency) scores. Thereafter, these set of scores were statistically analysed using ANCOVA.

4.2.1 Experimental Group comparison

The experimental group consisted of 15 children (n = 15). As can be seen from Table 7a, a positive effect of the water activities programme on the motor proficiency of the experimental group was revealed. The mean differences between Test 1 and Test 2 are displayed as well as the level of significance (both statistical and practical).

TABLE 7a: THE MEAN DIFFERENCES IN THE MOTOR PROFICIENCY OF THE EXPERIMENTAL GROUP BETWEEN TEST 1 AND TEST 2

EXPERIMENTAL GROUP											
	Test 1		Test 2		Meaningful Difference						
Variable	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**t-value**	**p**		**Cohen's d**	
GMS	57.67	30.08	65.4	32.65	**7.73**	11.19	2.68	**0.018**	*	**0.25**	#
ULC	9.8	5.43	17.73	3.83	**7.93**	4.92	6.24	**0.000**	**	**1.69**	##
FMS	16.87	18.36	47.93	25.82	**31.07**	25.86	4.65	**0.000**	**	**1.39**	##
BAT	33.6	24.39	62.47	30.62	**28.87**	16.9	6.62	**0.000**	**	**1.04**	##

** = statistically significant at 0.05 level; ** = statistically significant at 0.01 level*
 # = moderate practical significance (0.20 < d < 0.80); ## = large practical significance (d ≥ 0.80)

The mean improvement in gross motor skills was M = 7.73 (S.D. = 11.19), which was statistically significant (p = 0.018) and of moderate practical significance (d = 0.25). The mean performance scores for upper limb coordination, fine motor skills as well as overall motor proficiency indicated large statistically significant increases between Test 1 and Test 2 (p > 0.01) and large practical significance (d > 0.80) were observed. Significant differences were also indicated between Test 1 and Test 2 for the experimental group overall (p = 0.000 and d = 1.04), however, large standard deviations reflected large variability within the group. Nevertheless, a significant intervention effect was observed for the experimental group.

4.2.2 Control Group comparison

In contrast to the experimental group, the control group displayed no statistically significant change in their performances on the BOTMP between Test 1 and Test 2. In fact, the mean scores for three of the four variables decreased with one of the

three variables namely GMS indicating a deterioration of moderate practical significance (d = 0.26). Refer to Table 7b for the results of the control group.

TABLE 7b: THE MEAN DIFFERENCES IN THE MOTOR PROFICIENCY OF THE CONTROL GROUP BETWEEN TEST 1 AND TEST 2

CONTROL GROUP											
	Test 1		Test 2		Meaningful Difference						
Variable	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**t-value**	**p**		**Cohen's d**	
GMS	71.31	33.9	61.94	38.66	**-9.38**	17.97	-2.09	**0.054**	**-**	**0.26**	#
ULC	12.44	5.27	11.31	6.69	**-1.13**	3.12	-1.44	0.169	-	0.19	-
FMS	37.94	27.51	38.56	33.36	**0.63**	17.86	0.14	0.891	-	0.02	-
BAT	55.94	36.31	52.25	41.88	**-3.69**	10.64	-1.39	0.186	-	0.09	-

** = statistically significant at 0.05 level; ** = statistically significant at 0.01 level*
 # = moderate practical significance (0.20 < d < 0.80); ## = large practical significance (d ≥ 0.80)

A small increase between Test 1 and Test 2 was observed for the fine motor skills variable, with a mean improvement of M = 0.63 (S.D. = 17.86), but this difference was not statistically significant. It may therefore be concluded that no positive changes were found in the performances of the control group over the two tests.

4.2.3 Comparison between Experimental and Control Groups

To further evaluate the effect seen in the experimental group, the two groups (n = 31) were compared between Test 1 and Test 2, utilizing ANCOVA. Table 7c reflects these comparisons.

TABLE 7c: THE COMPARISON BETWEEN THE EXPERIMENTAL AND CONTROL GROUPS BETWEEN TEST 1 AND TEST 2

VARIABLES	EXP Mean Difference		CON Mean Difference		ANCOVA				
	Mean	**S.D.**	**Mean**	**S.D.**	**F**	**p-value**		**Cohen's d**	
GMS	7.73	11.19	-9.38	17.97	9.39	**0.005**	**	**1.13**	##
ULC	7.93	4.92	-1.13	3.12	33.33	**0.000**	**	**2.21**	##
FMS	31.07	25.86	0.63	17.86	9.88	**0.004**	**	**1.38**	##
BAT	28.87	16.90	-3.69	10.64	42.62	**0.000**	**	**2.32**	##

*** = statistically significant at 0.01 level; ## = large practical significance (d >= 0.80)*

A comparison of the results of Test 1 and Test 2 for the experimental and control groups showed that statistically and practically significant differences were observed for each variable. The overall motor proficiency score (BAT) revealed a significant mean difference of M = 28.87 (F = 42.62; p < 0.0005; d = 2.32). ANCOVA, therefore, confirmed the statistical significance of the effect of the water-based programme on the experimental group. Table 7c gave further support to the finding that an intervention effect had indeed been obtained.

4.3 MOTOR PROFICIENCY ONE MONTH AFTER COMPLETION OF THE WATER-BASED ACTIVITIES PROGRAMME

Only the children (n = 17) from School B took part in a third test, the retention test, which was completed one month after the second test. This enabled the researcher to establish a retention effect in motor proficiency after the conclusion of a water-based programme. The BOMTP was again used as the measuring instrument, and the test was conducted in the same way as was done for Test 1 and Test 2.

4.3.1 Retention in Experimental Group

Table 8a reflects amongst other results the t-test scores obtained from the experimental group (n = 8). The Pearson Correlation Coefficient (r), also reflected in Table 8a, describes the relationship between Test 2 and the retention test scores. Although the sample was small, some indication of retention during the time after completion of the intervention could be established.

TABLE 8a: RETENTION TEST RESULTS FOR THE EXPERIMENTAL GROUP AFTER ONE MONTH

Variables						t-Test		Pearson Correlation	
	N	Mean	S.D.	Min.	Max.	Stat.	p-value	r	p-value
GMS3 - GMS2	8	-6.50	24.32	-38	21	-0.76	0.474	0.137	0.727
ULC3 – ULC2	8	-4.25	2.60	-9	0	**-4.61**	**0.002**	**0.861**	**0.004**
FMS3 - FMS2	8	4.00	29.54	-38	45	0.38	0.713	-0.015	0.971
BAT3 – BAT2	8	-11.00	20.63	-30	28	-1.51	0.175	0.470	0.209

3 = retention test/test 3; 2 = post-test/test 2

Negative t-test scores indicated decreased performances in gross motor skills, fine motor skills and total motor proficiency in the experimental group. The only significant decrease in performance between Test 2 and Test 3 was in upper limb coordination (t = -4.61, p = 0.002). A slight increase in performance in fine motor skills was observed, but this was not statistically significant, neither was the overall negative change in motor proficiency statistically significant. In summary, therefore, the only change seen in the experimental group was in upper limb coordination, which showed a significant decrease in performance. Furthermore, this decrease seemed to be experienced by all in the group as a highly significant correlation for upper limb coordination between Test 2 and Test 3 was observed.

4.3.2 Retention in Control Group

Results indicate that the control group demonstrated a slight decrease in performance between Test 2 and Test 3. Refer to Table 8b for the results obtained by the control group after the one-month period of retention.

TABLE 8b: RETENTION TEST RESULTS FOR THE CONTROL GROUP AFTER ONE MONTH

Variables						t-Test		Pearson Correlation	
	N	Mean	S.D.	Min.	Max.	Stat.	p-value	r	p-value
GMS3 - GMS2	9	-17.67	19.03	-45	2	**-2.78**	**0.024**	0.419	0.233
ULC3 - ULC2	9	-2.00	6.14	-13	8	-0.98	0.357	-0.329	0.357
FMS3 - FMS2	9	0.00	21.57	-28	38	0.00	1.000	0.641	0.051
BAT3 - BAT2	9	-15.44	15.38	-41	11	**-3.01**	**0.017**	**0.741**	**0.017**

3 = retention test/test 3; 2 = post-test/test 2

Like the experimental group, the control group indicated negative mean difference scores between Tests 2 and 3 in gross motor skills, upper limb coordination and overall motor proficiency. However, decreased performances were only significant for the gross motor skills (p = 0.024) and the overall motor proficiency (p = 0.017). This decrease in the overall motor proficiency score seemed to affect the whole control group as a strong relationship between Test 2 and Test 3 was observed (r = 0.741; p = 0.017). The mean for fine motor skills revealed no change between Test 2 and Test 3 for the control group (M = 0.00; S.D. = 21.57). This result appears to

apply to the whole group due to the significant relationship depicted between the Test 2 and Test 3 scores (r = 0.641; p = 0.051).

4.4 MOTOR PROFICIENCY AT THE END OF THE STUDY

After three months, Test 3 was conducted to establish changes since Test 1. Only seventeen (17) of the 31 children participated.

4.4.1 Experimental Group after three months

Table 9a reflects the change in motor proficiency of the experimental group (n = 8), over a period of three months, i.e. between Test 1 and Test 3.

TABLE 9a: MOTOR PROFICIENCY SCORES FOR THE EXPERIMENTAL GROUP AFTER THREE MONTHS

Variables						t-Test		Pearson Correlation		Cohen's d
	N	Mean	S.D.	Min.	Max.	Stat.	p-value	r	p-value	
GMS3 – GMS1	8	2.38	20.11	-28.00	25.00	0.33	0.748	0.499	0.179	0.13
ULC3 – ULC1	8	1.75	3.92	-4.00	8.00	1.26	0.247	0.619	0.082	**0.40**
FMS3 – FMS1	8	34.63	38.30	-20.00	84.00	**2.56**	**0.038**	-0.380	0.319	**1.50**
BAT3 – BAT1	8	20.50	22.81	-23.00	45.00	**2.54**	**0.039**	0.388	0.308	**1.00**

1 = test 1/pre-test; 3 = test 3/retention test

The observed positive mean values indicate improvements in performance in all the variables for the experimental group. The largest mean differences observed were for fine motor skills (M = 34.63, S.D. = 38.30) and overall motor proficiency (M = 20.50, S.D. = 22.81), both being statistically (p = 0.038; p =0.039) and practically (d = 1.50; d = 1.00) significant.

4.4.2 Control Group after three months

The control group consisted of nine children (n = 9) who participated in the last test after three months. Table 9b indicates the motor proficiency scores of the control group as displayed after the three-month period of the study.

TABLE 9b: MOTOR PROFICIENCY SCORES FOR THE CONTROL GROUP AFTER THREE MONTHS

Variables						t-Test		Pearson Correlation		Cohen's d
	N	Mean	S.D.	Min.	Max.	Stat.	p-value	r	p-value	
GMS3 – GMS1	9	-18.33	18.03	-44.00	-2.00	**-3.05**	**0.016**	0.542	0.111	**1.18**
ULC3 – ULC1	9	-1.67	6.61	-10.00	8.00	-0.76	0.471	-0.418	0.235	**0.42**
FMS3 – FMS1	9	5.89	26.51	-29.00	54.00	0.67	0.524	0.346	0.332	0.25
BAT3 – BAT1	9	-13.78	19.04	-41.00	21.00	-2.17	0.062	0.502	0.144	**0.79**

1 = test 1/pre-test; 3 = test 3/retention test

A decrease in performance between Test 1 and Test 3 was observed in the control group, except in fine motor skills (M = 5.89, S.D. = 26.51) that confirmed a positive mean difference. However, only the negative changes in gross motor skills were statistically and practically significant (p = 0.016; p = 1.18). Deterioration of statistical significance in the execution of gross motor skills and a deterioration of practical significance in upper limb coordination and overall motor proficiency were observed for the control group.

4.5 INDIVIDUAL SUBJECT SCORES

Raw scores of individual subjects are observed in Tables 10a and 10b. The cut-off point for DCD on the BOTMP is 42 for at least one of the three composites, but the Upper Limb Coordination variable (ULC) does not provide a cut-off score in the BOTMP test and was therefore excluded in the presentation of the raw scores.

4.5.1 Subject Scores of the Experimental Group

Table 10a provides a detailed description of the motor proficiency in the experimental group throughout the three-month period of the study. The highlighted subject scores are those that were under the cut-off point for DCD (42 or less for at least one of the composites).

TABLE 10a: RAW SET OF SCORES FOR THE EXPERIMENTAL GROUP

EXPERIMENTAL GROUP RAW SCORES												
SUBJECTS	**GMS**			**FMS**			**BAT**			**DCD**		
	T1	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**
1	53	62	-	**39**	57	-	48	64	-	**Yes**	No	-
2	64	64	-	**41**	50	-	52	58	-	**Yes**	No	-
3	**33**	**41**	-	**20**	**30**	-	**20**	**35**	-	**Yes**	**Yes**	-
4	47	47	-	**40**	60	-	**37**	52	-	**Yes**	No	-
5	48	50	-	**36**	**40**	-	**39**	49	-	**Yes**	**Yes**	-
6	**39**	**28**	-	**21**	**35**	-	**26**	**32**	-	**Yes**	**Yes**	-
7	**33**	**40**	-	**32**	49	-	**32**	43	-	**Yes**	**Yes**	-
15	56	57	69	**29**	56	61	43	60	55	**Yes**	No	No
16	65	70	63	**35**	52	44	51	63	56	**Yes**	No	No
17	56	56	65	**41**	44	56	49	53	63	**Yes**	No	No
18	62	59	71	**36**	55	57	51	58	65	**Yes**	No	No
19	53	56	46	**36**	45	52	**40**	50	43	**Yes**	No	No
20	55	70	63	50	55	45	51	68	57	No	No	No
21	56	60	54	52	51	47	55	57	49	No	No	No
22	58	68	52	48	52	59	52	63	55	No	No	No
Total DCD										**11**/15 73%	**4**/15 27%	-

T1 = Test 1/pre-test; T2 = Test 2/post-test; T3 = Test 3/retention test

As indicated in Table 10a, twelve children in the experimental group had scores under the cut-off point for DCD in Test 1. In Test 2, however, only four of the twelve children were still under the cut-off score. The following were observed for the four cases that remained DCD at Test 2:

- Subject 3: although still scoring below the cut-off point, Subject 3 indicated improvement.

- Subject 5: only showed slight impairment in fine motor skills.

- Subject 6: indicated impairment in all the variables, but improved on fine motor skills and overall motor proficiency.

- Subject 7: indicated impairment only in gross motor skills.

4.5.2 Subject Scores of the Control Group

Large variability was observed in the control group as it consisted of 6 children with DCD and 10 children without. This is evident in Table 10b, indicating that Subjects 8-14 had much lower scores than subjects 23-31.

TABLE 10b: RAW SET OF SCORES FOR THE CONTROL GROUP

CONTROL GROUP RAW SCORES												
SUBJECTS	**GMS**			**FMS**			**BAT**			**DCD**		
	T1	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**	**T1**	**T2**	**T3**
8	**33**	**36**	-	**33**	**29**	-	**27**	**26**	-	**Yes**	**Yes**	-
9	55	50	-	47	**32**	-	47	**36**	-	No	**Yes**	-
10	52	**42**	-	**34**	**41**	-	43	**38**	-	**Yes**	**Yes**	-
11	**32**	**38**	-	**22**	**35**	-	**24**	**31**	-	**Yes**	**Yes**	-
12	57	45	-	**41**	**40**	-	**42**	**42**	-	**Yes**	**Yes**	-
13	53	**39**	-	**37**	**37**	-	43	**31**	-	**Yes**	**Yes**	-
14	41	**38**	-	44	**32**	-	**41**	**33**	-	**Yes**	**Yes**	-
23	58	59	49	51	45	44	56	53	46	No	No	-
24	71	76	51	45	43	53	62	64	53	No	No	-
25	73	80	69	62	79	62	70	80	64	No	No	-
26	70	66	51	50	48	**42**	58	58	47	No	No	**Yes**
27	73	76	65	59	57	57	68	68	61	No	No	-
28	62	59	60	46	52	62	55	58	63	No	No	-
29	77	80	68	47	52	52	66	70	60	No	No	-
30	72	68	66	50	59	51	65	66	59	No	No	-
31	63	65	54	57	61	59	58	60	57	No	No	-
Total DCD										**6**/16 38%	**7**/16 44%	**1**/9 11%

T1 = Test 1/pre-test; T2 = Test 2/post-test; T3 = Test 3/retention test

Six children had impairment in at least one of the variables in Test 1. Two of the children who did not previously indicate DCD, did so after Test 2 (Subject 9) and Test 3 (Subject 26):

- Subject 9 confirmed impairment with a score of 32 on fine motor skills and 36 on overall motor proficiency

- Subject 26 indicated a slight impairment in fine motor skills after the retention period with a score of 42.

In further support of the statistical findings mentioned earlier, inspection of individual results of the control group revealed relative consistency throughout the study. This confirms the statement made earlier that no drastic or significant change in their motor proficiency was observed.

These findings must now be discussed and conclusions drawn, to make it possible for recommendations to be put forward.

CHAPTER FIVE

DISCUSSION AND CONCLUSIONS

5.1 INTRODUCTION

This chapter aims to reflect on the results obtained in accordance with the objectives of the study. A description of the motor proficiency of the sample is given with a discussion of the variability found within the group itself. Thereafter, the effect of the water-based activities programme on the gross motor skills, fine motor skills and overall motor proficiency of the experimental group is examined by comparing the group to itself between Test 1 and Test 2, as well as by comparing the experimental group with the control group. The possibility of retention is discussed focusing on coordinated movement, incorporating the upper limb coordination variable, as well as determining whether retention was found within the experimental group by evaluating the group's performance throughout the study period. Individual performances are discussed in relation to the analysis done in Chapter 4. Recommendations for future research complete the report on this study.

5.2 THE EFFECT OF THE WATER-BASED ACTIVITIES PROGRAMME

It is clear from the results of this investigation that the experimental and control groups did not start on an equal basis, and both groups revealed variable motor proficiency scores after the start of the study. The latter is confirmed by the large standard deviations for both sample groups. Of the fifteen (15) children in the experimental group, twelve (12) children indicated signs of DCD and three did not, and of the control group, six children indicated DCD and ten (10) did not.

The selection procedures of the study were not strict enough to minimize such variability. Thus, when the motor proficiency was identified for the experimental and control groups, it differed as both group's contained DCD children and non-DCD

children. In addition, due to the heterogeneous nature of DCD, the DCD subjects had impairments on different variables of motor proficiency, which made it difficult to conclude that the programme had an effect on a specific variable for the group as a whole. Wright and Sugden (1996) indicated that children with DCD are clearly different from non-DCD children but also different amongst themselves. This again points to the fact that intervention programmes need to be designed according to individual children. Thus, a water-based programme may focus on individual performance, as the movements performed in water are slower, and developed at each child's pace and level. The fact that children from School B were not previously diagnosed with DCD proves that the problem of DCD exists in many schools and that little awareness of this disorder is provided for teachers and/or parents.

In spite of the variability, the children in the experimental group improved their overall motor proficiency after the eight-week water-based programme. Only four out of the 15 children in the experimental group still experienced signs of DCD in Test 2, which was conducted after the programme. Furthermore, the control group experienced minimal changes throughout the eight-week period as they continued with daily activities.

Due to the involvement of the whole body when executing movements in a water medium, children learned new motor skills and overcame obstacles without even realising it. This was mainly due to the natural resistance that water offers and the enjoyment of playing in the water. Fear of falling or hurting oneself is eliminated, thereby generating confidence in the child when moving and playing in the water. The positive improvement in motor proficiency of the experimental group, showed that the motor skills the children learned and participated in during the water programme, improved their motor skill performance on land.

Fourteen of the children in this study underwent occupational and physiotherapy during the programme. Seven of these fourteen children formed part of the control group and did not show any improvement throughout the three months of the study. When physiotherapy and occupational therapy are used in combination with a water-based programme, improvement in motor proficiency could be far reaching.

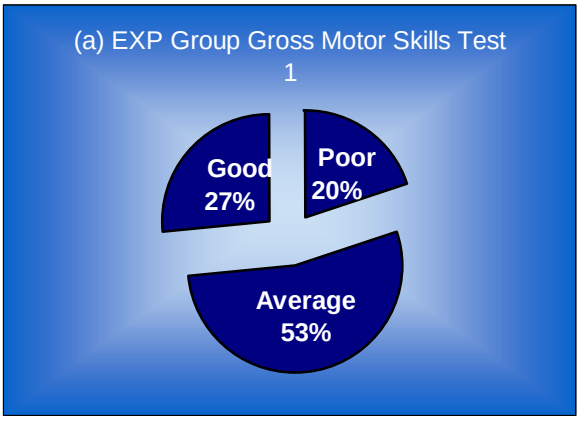
Research indicates (Skinner and Piek, 2001; Barnhart *et al.,* 2003), and it was the subjective experience of the researcher during the study, that children with DCD indicated low self-esteem and psychosocial problems on a continuous basis. Although this was not formally proven, the attention the children received from the instructor could be of definite value in improving the self-confidence of the child and could be another factor that contributed to the improved performance of the experimental group. A more specific discussion on how the gross and fine motor skills of the experimental group differed from the control after the intervention programme will follow.

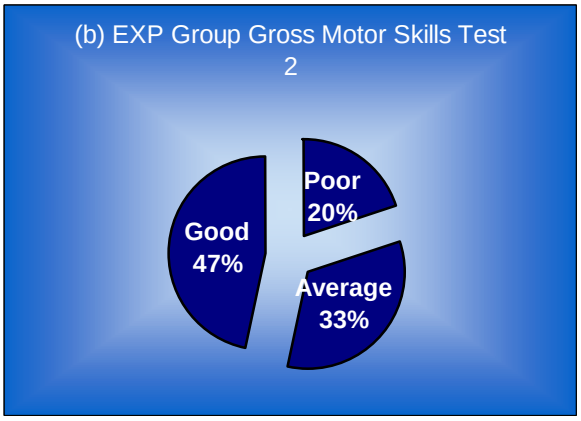
5.2.1 The effect on gross motor skills

When at first children are faced with the challenge of swimming or participating in water activities, the movement required would utilize the gross motor skills. Barnhart *et al.* (2003) indicated that DCD children showed signs of certain factors (primitive reflexes, hypotonia and immature balance) that interfered with gross motor development. It is therefore understandable that the DCD subjects involved in the study struggled with their gross motor performances (refer to Table 7a and 7b in Chapter 4).

Examples of gross motor skills practised in the water included large elementary movements such as climbing in and out of the pool, running in the water or using upper body limbs to move in the water through various swimming strokes. The resistance of the water offered the child the opportunity to exercise gross motor skills without conscious decision-making. Some effect on the gross motor skills was therefore expected, as they were used in all the activities during the programme (refer to appendix E). With the water-based programme, care was taken not to specifically simulate any of the activities in accordance with those in the BOTMP.

Figures 2(a) and 2(b) graphically indicate the frequency distributions before and after the water activities programme. The experimental group had a significant improvement in their gross motor skills performance after the water-based activities programme ($p < 0.05$).





FIGURES 2: FREQUENCY DISTRIBUTIONS OF THE EXPERIMENTAL GROUP'S GROSS MOTOR SKILLS (a) BEFORE INTERVENTION (TEST 1) AND (b) AFTER INTERVENTION (TEST 2).

Poor performances indicated a score under the cut-off point for DCD, which is a score on the BOTMP of 42 or less. As indicated in Figure 2(a) and 2(b), 20% of the children in the experimental group appeared to have a poor score before and after the intervention programme. However, in the individual analysis of the gross motor skills (refer to section 5.4), every child in the experimental group had a better score at the end of Test 2, so that although 20% (3 children) of the experimental group scored poorly in Test 2, their scores were better than their original Test 1 scores. The three children (20%) who still indicated poor scores were also the only three in the experimental group to still indicate DCD on the BOTMP after the intervention programme. Note that only 27% of the children appeared to have scores well above the cut-off point for DCD (a score of 43 or more on the BOTMP) before the intervention programme. This percentage changed to 47% after the water-based programme, with seven of the 15 children scoring well above the cut-off point on the BOTMP.

The control group had a significant decrease (statistically and practically) in their gross motor skills that implies the weakening of the large muscle groups without necessary practice. The decrease in the performance of the control group, who although not all identified with DCD, had overall relatively low motor proficiency scores. This reveals the importance of learning and practising gross motor

movements and should form part of the child's intervention programme as these fundamental skills form the basis of coordinated movement.

5.2.2 The effect on fine motor skills

Deficient fine motor skills are a major diagnostic factor in identifying DCD children. Difficulties with fine motor skills were also one of the reasons that therapists and teachers recommended the current subjects to participate in this study. When a lack in the ability to handle fine motor skills presents itself, children not only suffer physical consequences, but psychosocial consequences as well. This was visible in this study with fine motor skills being the one variable that both groups, experimental and control, found challenging. Coetzee, Pienaar and Aucamp (2001) found in their study that most of the children in the North-West Province of South Africa had low fine motor skill competency and ascribed it to the increasing sedentary lifestyle of modern day children. Nevertheless, the idea that water activities could improve or rectify fine motor skill deficits was doubtful at the onset of the study. Although the focus of the intervention programme was mainly on gross motor skills, the researcher was nonetheless interested in the transfer value of these experiences and success to proficiency in fine motor skills.

The results indicated that fine motor skills improved significantly in the experimental group. Test 1 provided a mean score of M = 16.87 (S.D. = 18.36), with Test 2 indicating a mean score of M = 47.93 (S.D. = 25.82) (see Table 7a in Chapter 4). This provided a mean difference between the two tests of M = 31.07 (S.D. = 25.86), the largest improvement of all variables. To further demonstrate the increase in performance in fine motor skills for the experimental group, large statistically and practically significant improvements in performance were revealed ($p = 0.000$, $d = 1.39$). In contrast to the increase in performance by the experimental group, the control group did not have any significant change in their fine motor skills in Test 2. In comparing the experimental group to the control group, the significant positive effect of the water-based programme on fine motor skills was supported ($p = 0.004$, $d = 1.38$).

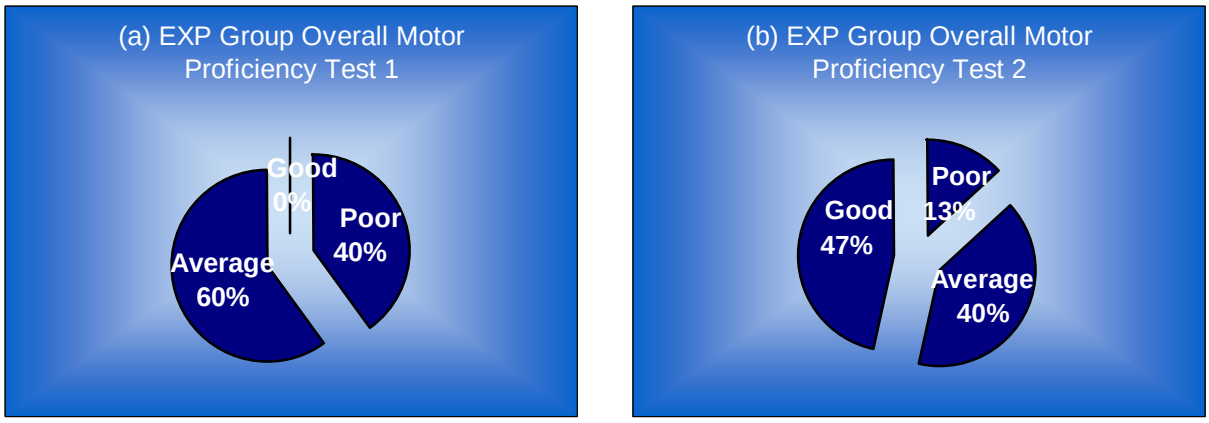
The ability to perform fine motor skills, results from learning and mastering the initial fundamental movements (Gallahue, 2000: 277). Accordingly, the child uses these fundamental skills for the performance of accurate and controlled specialised skills such as fine motor skills (refer to section 2.4.3 in Chapter 2).

The development of the gross motor skills through the repetition and practising of swimming skills seems to have led to the improvement in fine motor skills. Geuze *et al.,* (2001) suggested (refer to section 2.6.3) that balance training is a prerequisite for skills such as handwriting, which is considered a fine motor skill. As balance is a skill required to perform many water activities, this could have led to the improvement in fine motor skills in the experimental group. In addition, overcoming an obstacle such as the fear of water or being exposed to a foreign environment together with peers can generate confidence and pride. This feeling of confidence could also have transferred to other activities such as writing or drawing (fine motor skills), making them easier to perform. However, the explanation offered requires further research for confirmation.

5.2.3 The effect on overall motor proficiency

The overall motor proficiency scores (BAT) of the two groups incorporated gross motor and fine motor skills, as well as upper limb coordination. When an intervention programme manages to improve overall motor proficiency as well as focus on individual needs, it may be considered effective. The results indicated that the overall motor proficiency of the experimental group improved significantly after the water-based programme ($M = 28.87$; $S.D. = 16.9$; $p < 0.01$; $d = 1.04$).

Figures 3(a) and 3(b) reflect these improvements graphically. As Figure 3(a) indicates, the motor proficiency of the children in the experimental group in Test 1 indicated 60% (nine children) scored just above the cut-off point for DCD and 40% were below. After the intervention, only 13% (2 children) indicated DCD in their overall motor proficiency (refer to Individual Analysis in section 5.4) and 47% (7 children) performed well above.



FIGURES 3: FREQUENCY DISTRIBUTIONS OF EXPERIMENTAL GROUP'S OVERALL MOTOR PROFICIENCY (a) BEFORE THE INTERVENTION AND (b) AFTER THE INTERVENTION.

As most of the control group did not indicate DCD in Test 1 (only 6 children with DCD), results should be more consistent throughout the study. Thus, after 2 months no significant change was evident in their overall motor proficiency. However, for the children without DCD, the individual results did reflect a steady improvement in results, which can be ascribed to normal growth and maturation of children without a developmental delay.

5.3 THE POSSIBILITY OF RETENTION

The study proved that the children were able to improve their motor proficiency, after a two-month water-based intervention programme. However, the question was also asked as to whether the training effect could be maintained for a period of one month without any special intervention. A significant decrease in upper limb coordination performance was found in the experimental group after the cessation of the programme.

5.3.1 The retention of coordinated movement

One common indicator of DCD is delayed motor-skill development and, essentially, DCD children do not acquire sufficient skills to handle coordinated environmental

task demands, such as catching a ball. The upper limb coordination task of the BOTMP was singled out as a specific indicator of coordinated movement and it challenged the child to utilise throwing and catching skills in various ways. As DCD children struggle to coordinate movement (Mandich *et al.*, 2002), when the opportunity to practise coordinated skills ceases to exist, the decline in this area could be the most significant finding. In such circumstances, the doing away with physical education periods during school, or just the lack of participating in play on the playground or at home, can lead to further deterioration in coordinated movement. Some children with DCD have considerable difficulty with ball-related activities. Suggestions as to why this problem exists were recorded by researchers (Lefebvre and Reid, 1998) as being visually related or as having lack of experience. Children with DCD can also be distinguished from non-DCD children by analysing catching performance (Hoare, 1994; Lefebvre and Reid, 1998).

Through the practice of asymmetrical movements required for most swimming actions, children could use the opportunity to improve their coordinated movements. The repetition that was required for this asymmetrical movement thus contributed to the ability to coordinate all four limbs, and therefore integrate more muscle groups. Throughout the intervention programme, the experimental group exercised upper limb muscles through various swimming actions and playing games involving throwing and catching in the water (see Appendix E). All the above-mentioned factors could explain the substantial increase in the mean performance of upper limb coordination for the experimental group immediately after the water-based programme.

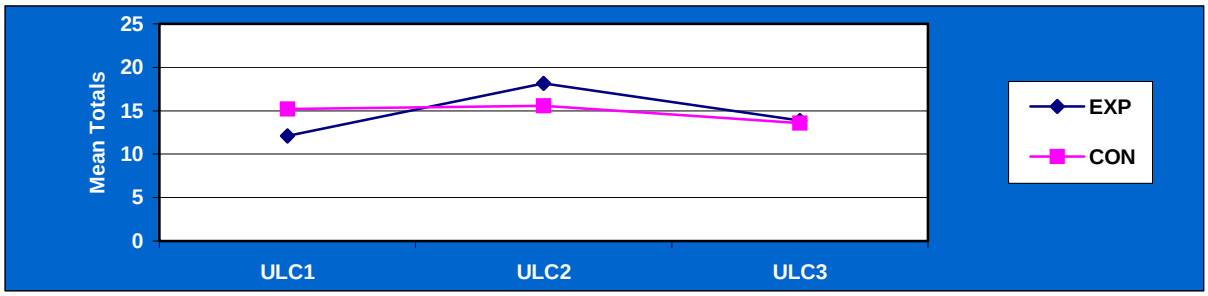


FIGURE 4: UPPER LIMB COORDINATION PERFORMANCES FOR THE EXPERIMENTAL AND CONTROL GROUPS (n = 17)

Figure 4 depicts the improvements made by the experimental group in comparison with the control group over the full duration of the study (three months). A relatively stable performance can be seen throughout the study for the control group, as no significant changes were indicated. After the retention period (which lasted one month after the completion of the water activities programme), the experimental group revealed a significant decrease in upper limb coordination (ULC2 = 18.12; ULC3 = 13.87). This is depicted in Figure 4 and can be attributed to the sudden cessation in the repetition of coordinated movements. In addition, the programme was only administered twice a week for 30 minutes due to time restrictions. However, this decrease was only significant in upper limb coordination which confirms that with the cessation of practising coordinated movement, what had been gained previously could be lost just as rapidly. However, the experimental group still managed to obtain a better score in upper limb coordination than at the start of the study.

In contrast, a non-significant decrease in upper limb coordination by the control group (see Figure 4) could be attributed to children not receiving any opportunity to practise coordinated movement. After retention, the control group again did not show any significant change in upper limb coordination. In contrast to the dramatic decrease in upper limb coordination experienced by the experimental group, the control group stayed consistent throughout the study and did not indicate any significant decreases or increases in upper limb coordination. Concern may therefore be raised as to where and how coordinated movement can be exercised in children with a developmental delay if not through some form of organized activities programme, be it a water activities programme or another specialised intervention method.

5.3.2 The lasting effect of the programme

Erbaugh (1986) reported that when children learn swimming skills, this has a positive impact on their motor development. This statement was also supported by Councilman (1982), Langendorfer (1990), Langendorfer and Bruya (1995), Nearing *et al*. (1995) and Braun (1997). A water-based programme that is presented to

children in their developing years could therefore have a definite impact on their general, as well as specific, motor proficiency.

Only 17 subjects (n = 17) participated throughout the whole three months of the study, as only these subjects underwent the third test, the retention test. In a comparison between Test 1 and Test 3, it was found that for the period of the study, which was approximately three months, the experimental group experienced significant change, as indicated by the t-test.

Figure 5 reflects the overall motor proficiency score for the sample of subjects (n = 17). The results from the experimental group revealed a significant increase in overall motor proficiency in Test 2 (BAT2 = 78.37, S.D. = 23.16; t = 2.54; p = 0.039). In comparison with the performance in Test 1, Test 3 indicated better results on all the variables for the experimental group.

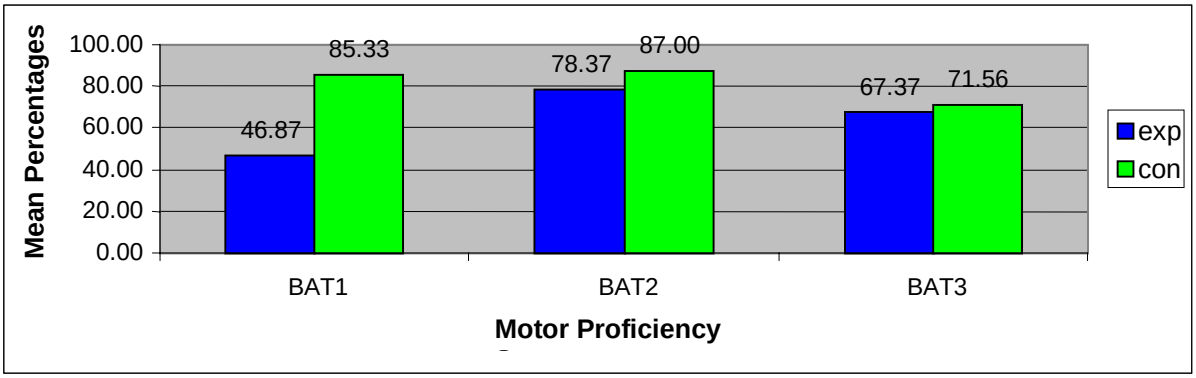


FIGURE 5: OVERALL MOTOR PROFICIENCY PERFORMANCE FOR THE SAMPLE OF SUBJECTS (n = 17)

A significant decrease in motor proficiency in Test 3 was found for the experimental group, but they had still gained significantly in overall motor proficiency since Test 1. The control group displayed similar scores between Test 1 and Test 2 (BAT1 = 85.33, S.D. = 10.84; BAT2 = 87.00, S.D. = 12.16). Although the control group experienced a decrease in motor proficiency in Test 3, it did not have any significant implications.

Figure 6 indicates the gross motor skills performance over the three tests for the sample (n = 17).

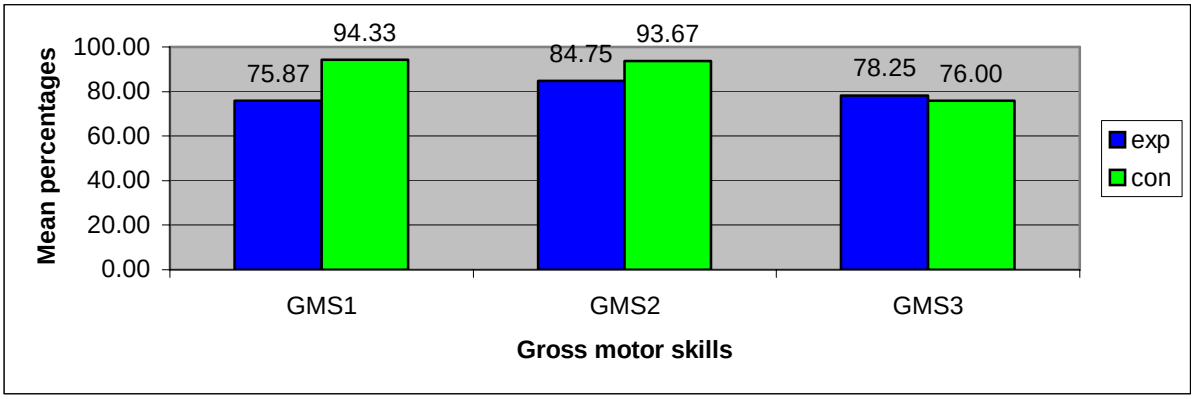


FIGURE 6: GROSS MOTOR SKILLS PERFORMANCE FOR THE SAMPLE OF SUBJECTS (n = 17)

Both groups finished on an equal level, with the experimental group having a slight advantage over the control group in Test 3 (EXP = 78.25; CON = 76.00). A significant decrease in gross motor skills was observed in the control group after the three months (GMS2 = 93.67; GMS3 = 76.00). Again, this reveals the importance of learning and practising gross motor movements that should form part of the child's physical activities intervention programme.

Figure 7 reveals the fine motor skill performance of both groups over the study period.

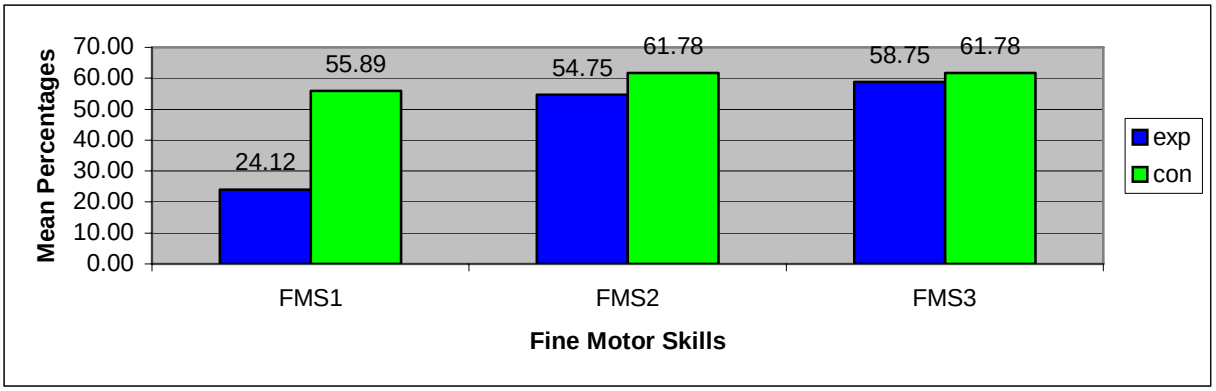


FIGURE 7: FINE MOTOR SKILLS PERFORMANCE FOR THE SAMPLE OF SUBJECTS (N = 17)

The significant difference is clearly visible between the groups in Test 1. However, the performances of the two groups all improved over the three months, but the experimental group increased significantly more than the control group. In fact, after the three-month period the experimental group had virtually eliminated their backlog.

The fact that positive changes in motor proficiency accompanied the experimental group after the water-based programme was an indication of the positive effect of using a water-based approach to improving motor skills in children with DCD. The ability of children with DCD varied from child to child, but with task-specific instruction, incorporating an environment unfamiliar to most of the children, a learning experience was provided that was individualised and specific to each child's needs. In addition, the fact that the programme, which was short and time-limited, still had an effect on motor proficiency, can only suggest that a continuous water-based programme could have a greater impact.

5.4 INDIVIDUAL ANALYSIS

Tables 10(a) and 10(b) in Chapter 4 revealed the raw scores of each of the subjects in their respective groups. As was indicated in these tables, only four of the 15 children in the experimental group still indicated DCD after the intervention programme.

Throughout the study, each child presented with his or her own unique qualities and abilities. The study sample was small enough to allow for the examination of individual abilities and thereby clarify the statistical findings for the total group.

The individual performances once again highlight the importance of designing an intervention programme that could appeal to and suit each child's needs. Henderson and Henderson (2002) recommended that intervention methods should provide a unique and individualised opportunity for the children involved in the rehabilitation. From the results, it was clear that individual subjects in the experimental group performed outstandingly well, as most of the children had never participated in a swimming programme before. An unfamiliar environment can allow for individual

exploration and at the same time provide an opportunity for participation amongst peers. Where a set programme was developed for the purpose of this study, the activities could be adapted to suit each child's level of ability. For example, an activity requiring the practising of balancing could be asking one child to kick on a kickboard and another to sit on a noodle. However, the principle of the activity remains the same but with varying levels of difficulty to suit the ability of each child.

To support the improvements found in the fine motor skills of subjects in the experimental group, teachers and therapists reported on the increase in confidence levels for specifically two subjects (Subjects 3 and 19). These two specifically were very quiet during the intervention programme, displaying fear of water and shyness. They both indicated DCD in Test 1 (refer to Table 10a), the worst performance being in fine motor skills, with Subject 3 indicating further impairment on all the variables. However, after the intervention programme, both were reported to have improved their handwriting in school. Both subjects overcame their fear of water and were much more talkative towards the end of the programme. Subject 19 scored well above the cut-off point for DCD and Subject 3 improved her score from Test 1. Subject 19 participated in the retention test and continued to show improvement.

Four children in the experimental group still indicated DCD after the intervention programme. As can be seen from Table 10a, all four subjects improved their total motor proficiency after the intervention, but they just did not manage to score above the cut-off point.

In the control group, seven children indicated DCD in Test 2. Subject 9 indicated impairment in fine motor skills and overall motor proficiency after Test 2, after not displaying DCD in Test 1. Subject 26 displayed borderline DCD in fine motor skills but only in the retention test. From Table 10b, it is clearly shown that the control group also experienced the most difficulty in fine motor skills, and some did manage to improve slightly on this variable. However, most of the control group managed to display consistency on all the variables, thus indicating that growth and maturation did not play a role in the improvement depicted in the experimental group.

Therefore, of the children who participated in the study, 18 were originally diagnosed with DCD, 12 of whom were in the experimental group and six of whom were in the control group. After the water-based intervention programme, only four of the 12 children in the experimental group still revealed scores reflective of DCD with all six children in the control group still indicating DCD.

5.5 CONCLUSION

In accordance with the objectives set for the study, the following conclusions can therefore be drawn:

- The motor proficiency of DCD children was variable within the DCD group as well as amongst their peers without DCD.

- The water-based activities programme had a significant positive effect on the experimental group's motor proficiency. Normal growth and development could not have accounted for this positive effect as a control group of matching age and gender (where possible), who did not experience the intervention programme, was used in the study to control for this effect.

- After the three-month duration of the study was taken into account, the experimental group indicated better performances at the end of the study than at the start, thereby confirming the positive and lasting effect of the water-based intervention programme.

5.6 LIMITATIONS

Certain limitations in the study were identified and need to be noted in order to interpret the findings appropriately.

They are listed as follows:

- The sample could be criticised as being too small (n = 31) and not completely representative of the total population. Larger numbers, however, would have implied including another set of experimental and control groups. The effect of the intervention programme could have been negatively affected by increasing the size of existing experimental groups. More sets of experimental and control groups were not practically possible to accommodate.

- The sample was not truly representative of the DCD population and included children with and without DCD. The total sample of subjects included in the study all had relatively low motor proficiency and were experiencing academic problems in the school.

- Due to the time limit of the study, the programme could only be conducted twice a week for 30 minutes per session over a period of eight weeks. Continuous exposure to this programme may have had greater positive effects on the motor proficiency of the subjects.

5.7 RECOMMENDATIONS FOR FUTURE RESEARCH

Given the limitations mentioned, the following recommendations for future research are suggested:

- A study in which a water-based programme is to be conducted over the long term (more than eight weeks) and on a continuous basis, especially when it involves children in the developing stages, could perhaps more clearly indicate the retention value of such a programme.

- A comparative study between a water-based programme and a land-based intervention would reveal any superiority that may exist.

- A similar study to the one conducted but involving a pure sample of children with DCD could highlight the specific value of such an intervention programme for children showing characteristics of this disorder.

This study has demonstrated that a water-based programme holds out hope of improvement for children with DCD and that further research could well be conducted fruitfully as recommended above.

REFERENCES

Armitage, M. and Larkin, D. (1993). Laterality, motor asymmetry and clumsiness in children. *Human Movement Science.* **12***:* 155-177.

Barnhart, R.C., Davenport, M.J., Epps, S.B. and Nordquist, V.M. (2003). Developmental Coordination Disorder. *Physical Therapy.* **83**:722-731.

Blake, K.T. and Anderson, C.W. (2002). Neuropsychological deficits underlying social skills weaknesses and strategies for remediation. International Dyslexia Association. 53rd Annual Conference. Atlanta, Georgia.

Braun, C. (1997). The effects of a water activities programme on the motor proficiency of children with Developmental Coordination Disorder. Unpublished Thesis. University of Stellenbosch, South Africa.

Bruininks, R.H. (1978). *Bruininks-Oseretsky test of motor proficiency: Examiner's Manual. pp 11-34, 142-147.* Circle Pines, MN: American Guidance Service, Inc.

Candler, C. and Meeuwsen, H. (2002). Implicit learning in children with and without Developmental Coordination Disorder. *The American Journal of Occupational Therapy.* **56**(4): 429-435.

Coetzee, M., Pienaar, A.E. and Aucamp, A. (2001). Manual dexterity skills of 10-12 year old children in the North-West Province of South-Africa: Usefulness of the M-ABC. *African Journal for Physical, Health Education, Recreation and Dance (AHPERD).* **7**(1): 165-178.

Councilman, J.E. (1982). *The science of swimming. pp 171-182.* Englewood Cliffs, New Jersey: Prentice-Hall, Inc.

Craig, G.J. (1996). *Human development. pp 154-266.* 7th ed. Upper Saddle River, New Jersey: Prentice-Hall, Inc.

Crawford, S.G., Wilson, B.N. and Dewey, D. (2001). Identifying Developmental Coordination Disorder: Consistency between tests. *Physical and Occupational Therapy in Pediatrics.* **20**(2-3): 29-50.

Dumas, H. and Francesconi, S. (2001). Aquatic therapy in pediatrics: Annotated bibliography. *Physical and Occupational Therapy in Pediatrics.* **20**(4): 63-78.

Erbaugh, S.J. (1986). Effects of aquatic training on swimming skill development of preschool children. *Perceptual and Motor Skills.* **62**: 439 - 446.

Fox, M. and Lent, B. (1996). Clumsy children: primer on Developmental Coordination Disorder. *Canadian Family Physician.* **42**: 1965-1971.

Gallahue, D.L. (2000). Motor development. In J.P. Winnick (Ed.). *Adapted Physical Education and Sport. pp 266-279.* Champaign, Illinois: Human Kinetics Publishers, Inc.

Gallahue, D.L. and Donnelly, F.C. (2003). *Developmental physical education for all children. pp 37-62.* Champaign, Illinois: Human Kinetics Publishers, Inc.

Geuze, R.H., Jongmans, M., Schoemaker, M and Smits-Engelsman, B. (2001). Developmental Coordination Disorder. *Human Movement Science.* **20** (1-2): 1-5.

Green, D., Baird, G., Barnett, A.L., Henderson, L., Huber, J. and Henderson, S.E. (2002). The severity and nature of motor impairment in Asperger's Syndrome: A comparison with specific developmental disorder of motor function. *Journal of Child Psychology and Psychiatry*. **43**(4): 655-688.

Gubbay, S.S. (1975). *The clumsy child. p 5.* London: W.B. Saunders Company, Ltd.

Hadders-Algra, M. (2000). The neuronal group selection theory: promising principles for understanding and treating developmental motor disorders. *Developmental Medicine and Child Neurology.* **42**(10): 707-715.

Harrison, J.A. (1989). *Anyone can swim: Understand and coping with special needs. pp 9-11*. Amateur Swimming Association. Marlborough: The Crowood Press.

Harvey, W.J. and Reid, G. (2003). Attention-Deficit/Hyperactivity Disorder: A review of research on movement skill performance and physical fitness. *Adapted Physical Activity Quarterly.* **20**(1):1-25.

Haywood, K.M. and Getchell, N. (2001). *Lifespan motor development. pp 20-23.* 3rd Ed. Champaign, Illinois: Human Kinetics Publishers, Inc.

Henderson, S.E. and Henderson, L. (2002). Toward an understanding of Developmental Coordination Disorder. *Adapted Physical Activity Quarterly.* **19**(1): 12-31.

Hoare, D. (1994). Subtypes of Developmental Coordination Disorder. *Adapted Physical Activity Quarterly.* **11**: 158-169.

Hoehn, T.P. and Baumeister, A.A. (1994). A critique of the application of sensory integration therapy to children with learning disabilities. *Journal of Learning Disabilities.* **27**(6): 338-351.

Kadesjo, B. and Gillberg,G. (1999). Developmental Coordination Disorder in Swedish 7-year old children. *Journal of the American Academy of Child and Adolescent Psychiatry.* **38**(7): 820-828.

Kadesjo, B and Gillberg, G. (2001). The comorbidity of ADHD in the general population of Swedish school-age children. *Journal of Child Psychology and Psychiatry and Allied Disciplines.* **42**: 487-492.

Langendorfer, S.J. (1990). Contemporary trends in infant/preschool aquatics: Into the 1990s and beyond. *Journal of Physical Education, Recreation and Dance.* **61**(5): 36-39.

Langendorfer, S.J. and Bruya, L.D. (1995). *Aquatic readiness developing water competence in young children.* Champaign, Illinois: Human Kinetics Publishers, Inc.

Latash. M.L. (1998). *Neurophysiological basis of movement*. Champaign, Illinois: Human Kinetics Publishers, Inc.

Leemrijse, C., Meijer, O.G., Vermeer, A., Ader, H.J. and Diemel, S. (2000). The efficacy of Le Bon Depart and Sensory Integration treatment for children with Developmental Coordination Disorder: A randomised study with six single cases. *Clinical Rehabilitation.* **14**(3): 247-260.

Lefebvre, C. and Reid, G. (1998). Prediction in ball catching by children with and without a Developmental Coordination Disorder. *Adapted Physical Activity Quarterly.* **15**(4): 299-315.

Levine, K.J. (2002). The Bruininks-Oseretsky Test of Motor Proficiency: Usefulness for assessing writing disorders. http://www.dartmouth.edu/ kjlevine/botmp.htm. 2003.

Losse, A., Henderson, S.E., Elliman, D., Hall, D., Knight, E. and Jongmans, M. (1991). Clumsiness in children: do they grow out of it? A ten-year follow up study. *Developmental Medical Child Neurology.* **33**: 55-68.

Maldonado-Duran, M., Glinka, J. and Lubin, S. (2002). Motor Skills Disorder. *eMedicine Journal*. **3**(2). 1-28. http://author.emedicine.com/ped/topic2640.htm. 2003.

Mandich, A.D., Polatajko, H.J., Macnab, J.J. and Miller, L.T. (2001). Treatment of children with Developmental Coordination Disorder: What is the evidence. *Physical and Occupational Therapy in Paediatrics.* **20**(2-3): 51-68.

Mandich, A., Buckolz, E. and Polatajko, H. (2002). On the ability of children with Developmental Coordination Disorder (DCD) to inhibit response initiation: The Simon Effect. *Brain and Cognition.* **50**(1): 150-162.

Miller, L.T., Missiuna, C.A., Macnab, J.J., Malloy-Miller, T. and Polatajko, H.J. (2001). Clinical description of children with Developmental Coordination Disorder. *Canadian Journal of Occupational Therapy.* **68**(1): 5-15.

Missiuna, C. (1994). Motor skill acquisition in children with Developmental Coordination Disorder. *Adapted Physical Activity Quarterly.* **11**(2): 214-235.

Missiuna, C., Malloy-Miller, T. and Mandich, A. (1997). Cognitive, or "Top-Down": approaches to intervention. *Neurodevelopmental Clinical Research Unit (NCRU).* http://www.fhs.mcmaster.ca/canchild/publications/keepcurrent/KC97-1.html. 2004.

Missiuna, C. (2001). Strategies for success: Working with children with Developmental Coordination Disorder. *Journal of Physical and Occupational Therapy in Paediatrics.* **20**(2-3): 29-50.

Mon-Williams, M.A., Wann, J.P. and Pascal, E. (1999). Visual-proprioceptive mapping in children with Developmental Coordination Disorder. *Developmental Medicine and Child Neurology.* **41**(4): 247-254.

Nearing, R.J., Johansen, D.A.K. and Vevea, C. (1995). Gymnastics mats in the pool? *Palaestra.* **11**(2):22-30.

Newcombe, N. (1996). *Child development: change over time*. New York: Harper-Collins, Inc.

Padayachie, R., Atmore, E., Biersteker, L., King, R., Matube, J., Muthayan, S., Naidoo, K., Plaatjies, D. and Evans, J.L. (1994). *Report of the South African study on Early Childhood Development: Recommendations for action in support of young children.* Johannesburg: Centre for Education Policy Development.

Peens, A., Pienaar, A.E., and Nienaber, A.W. (2004). Selfkonsep van 10- tot 12-jarige seuns en meisies met en sonder DCD in die Noordwes Provinsie. *Tydskrif vir Geesteswetenskappe.* **44**(1): 52-61.

Pienaar, A.E. (1995). The incidence and treatment of motor deficiencies in children six to nine years of age. Unpublished Proceedings (Part II) of the 1995 AIESEP World congress, June 26-30, Wingate Institutes, Netanya, Israel. 631-637.

Pless, M. and Carlsson, M. (2000). Effects of motor skill intervention on Developmental Coordination Disorder: A Meta-Analysis. *Adapted Physical Activity Quarterly.* **17**(4): 381-401.

Pless, M., Carlsson, M., Sundelin, C. and Persson, K. (2002). Preschool children with Developmental Coordination Disorder: a short-term follow-up of motor status at seven to eight years of age. *Acta Paediatrica Scandinavica.* **91**(5): 521-528.

Raynor, A.J. (1998). Fractionated reflex and reaction times in children with Developmental Coordination Disorder. *Motor Control.* **2**(2): 114-124.

Rhodes, L. (1993). *Successful Strokes. p 5*. The Department of Sport and The Environment and Territories and Australian Sports Commission: Australian Swimming, Inc.

Skinner, R.A. and Piek, J.P. (2001). Psychosocial implications of poor motor coordination in children and adolescents. *Human Movement Science.* **20**: 73-94.

Smits-Engelsman, B.C.M., Niemeijer, A.S. and Van Galen, G.P. (2001). Fine motor deficiencies in children diagnosed as DCD based on poor graphomotor ability. *Human Movement Science.* **20**: 161-182.

Sprinkle, J. and Hammond, J. (1995). Movement deprivation of children with Developmental Coordination Disorder: case study. Hobart, Tasmania: Australian Association for research in Education Conference.

Tervo, R. (2003). Identifying patterns of developmental delays can help diagnose neurodevelopmental disorders. *A Pediatric Perspective.* **12**(3): 1-6.

Tortora, G.J. and Grabowski, S.R. (2000). *Principles of anatomy and physiology. pp 4, 463-502.* 9th Ed. New York: John Wiley and sons, Inc.

Visser, J., Geuze, R.H. and Kalverboer, A.F. (1998). The relationship between physical growth, the level of activity and the development of motor skills in adolescence: Differences between children with DCD and controls. *Human Movement Science.* **17**(4-5): 573-608.

Visser, J. (2003). Developmental Coordination Disorder: A review of research on subtypes and comorbidities. *Human Movement Science.* **22**(4-5): 479-493.

Willoughby, C. and Polatajko, H.J. (1995). Motor problems in children with Developmental Coordination Disorder: A review of the literature. *The American Journal of Occupational Therapy.* **49**(8): 787-794.

Wilson, B., Kaplan, B.J., Crawford, S.G. and Dewey, D. (2000). Interrater reliability of the Bruininks-Oseretsky Test of Motor Proficiency-Long Form. *Adapted Physical Activity Quarterly.* **17**: 95-110.

Wright, H.D. and Sugden, D.A. (1996). The nature of Developmental Coordination Disorder: Inter- and intragroup differences. *Adapted Physical Activity Quarterly.* **139**(4): 357-371.

APPENDICES

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APPENDIX A

LETTER OF REQUEST TO CONDUCT RESEARCH IN THE PORT ELIZABETH SCHOOL DISTRICT

DEPARTMENT OF HUMAN MOVEMENT SCIENCE

9 August 2002

The District Manager
Port Elizabeth District
Private Bag X3931
NORTH END
6056

RE REQUEST TO CONDUCT RESEARCH IN THE PORT ELIZABETH SCHOOL DISTRICT

I am a student registered for the Masters Programme in the Faculty of Health Sciences at the University of Port Elizabeth. For the purpose of the programme, I need to conduct a research project in the form of a dissertation. I hereby apply for permission to conduct research in the Port Elizabeth School District. The purpose of this research is to determine the effect of a Water-Based Programme on the Motor Proficiency of Children with Developmental Coordination Disorder.

This study will require a minimum of 30 children from the Port Elizabeth School District. The programme will be conducted in the afternoon as an extramural activity and will be approximately 8 weeks long with two lessons per week, completing 16 lessons in total. Each lesson will be 30 minutes long. For evaluation purposes before and after the programme, each child will be tested according to a standardized test. A time of 45-60 minutes will be required for testing one child, prior and after the programme's completion. Attached please find my Proposal* that will provide detailed information on objectives of the study and the research method, which will be applied.

No school or child will be identified in the research report and strict confidentiality will be maintained. A brief summary of the research findings will be forwarded to the Department on completion of the study.

I trust that you will consider this request positively. Thank you in advance.

Christine Joubert
(Student Researcher)

Prof R Du Randt
(Supervisor)

* The proposal was not included in this report due to obvious overlaps that would exist between the latter and this final report on the study.

APPENDIX B

LETTER TO SCHOOL PRINCIPALS

UNIVERSITY OF PORT ELIZABETH
UNIVERSITEIT VAN PORT ELIZABETH
IYUNIVESITHI YASEBHAYI

DEPARTMENT OF HUMAN MOVEMENT SCIENCE

12 September 2002

Dear Sir/Madam

RE REQUEST TO CONDUCT RESEARCH

My name is Christine Joubert and I am a Masters student in Human Movement Science at the University of Port Elizabeth. The Masters course requires of me to conduct research on a specific topic.

I have chosen the topic: The Effect of A Water-Based Programme on the Motor Proficiency of Children with Developmental Coordination Disorder. Please refer to the attached Proposal* for details pertaining to the intended study. If the school allows me, I would like to include some of the children as potential participants in my study but will not in anyway pursue this until I have the permission of the parents involved, the child self, the therapists and the school.

* The proposal was not included in this report due to obvious overlaps that would exist between the latter and this final report on the study.

If you have any queries about my purpose and my study, please do not hesitate to contact me or my supervisor, Prof R Du Randt (Department of Human Movement Science, UPE) at 504 2499.

Yours sincerely,

Christine Joubert

APPENDIX C

ADULT INFORMED-CONSENT FORM

1. Christine Joubert, who is a Masters student in Biokinetics at the University of Port Elizabeth, has requested my minor child's participation in a research study at this institution. The title of the research is "*The Effect of an Water-Based Programme on the Motor Proficiency of Children with Developmental Coordination Disorder."*

2. "I have been informed that the purpose of the research is to determine the effects of the Water Activities Programme on the Motor Proficiency of my child."

3. "My child's participation will involve 2 days of pre-testing, 16 lessons in the pool, and 2 days of post-testing. If so required, my child will participate in a 2 days post-retention test."

4. "I understand there are discomforts to me and my child if I agree to my child's participation in this study. Possible discomforts include transport costs and arrangement as well as time commitment."

5. "I understand that the possible benefits of my child's participation in the research are that my child learns or improves new motor skills, as well as possible social skills, and possible improvement in his/her motor proficiency."

6. "I understand that the results of the research study may be published but that my child's name or identity will not be revealed."

7. "I have been advised that the research in which my child will be participating does not involve more than minimal risk. I understand that the investigator will ensure safety precautions in the testing area as well as the pool area by following strict safety rules. I understand that the instructors teaching my child are all qualified swimming instructors by LEARN TO SWIM, South Africa."

8. "I have been informed that I will not be compensated for my child's participation."

9. "I have been informed that any questions I have concerning the research study or my child's participation in it, before or after my consent, will be answered by Christine Joubert at 0827946426 or Prof Rosa Du Randt, Department of Human Movement Science, UPE at 504 2499."

10. "I understand that in case of injury, if I have any questions about my child's rights as a subject or participant in this research, or if I feel I have been placed at risk, I can contact the Chair of the UPE Human Ethics Committee."

11. “I have read the above information. The nature, demands, risks and benefits of the project have been explained to my child and me. I knowingly assume the risks involved, and understand that I may withdraw my consent and discontinue my child’s participation at any time without penalty or loss of benefit to myself or my child. In signing this consent form, I am not waiving any legal claims, rights or remedies. A copy of this consent form will be given to me.”

I, _____, parent of _____, hereby declare that I have received the letter where the exercise program study has been explained.

I also give permission for _____ to participate in the study and declare that the Department of Education as well as the school, will not be held liable for any injuries that may befall my child during transportation to and from the pool and during the participation in the exercise program.

Parent/Guardian signature…….Date……..

Signature of Investigator…….

APPENDIX D

CHILD CONSENT FORM

I, ……, understand that my mom and dad have given permission (said it's okay) for me to take part in a water activities program that will help me improve my movement skills, done by Christine Joubert.

I am taking part because I want to, and I have been told that I can stop at any time I want to and I will not get in trouble if I want to stop.

……..	…….
Signature	Date

APPENDIX E

THE WATER-BASED ACTIVITIES PROGRAMME

Lesson One

Purpose: Introductory, familiarise with water, enjoyment

Introduction: Walking/running in pool, Bunny hops, floating

Swimming: Kicking with boards, Intro bubbles and streamlining

Games: Paddle - front, back, side, shark and tuna

Lesson Two

Purpose: Introductory, familiarise with water, enjoyment

Introduction: Walking/running in pool, Bunny hops, floating

Swimming: Kicking with boards, bubbles and speedboat

Games: Paddle - front, back, side, shark and tuna

Lesson Three

Purpose: Running speed and coordination

Introduction: familiarise with water, north-south-east-west, kicking on side of pool, sliding in on tummy

Swimming: kick with board (assisted), speedboat, back kick with board (assisted), doggy swim, guiding arm action, slapping water

Games: underwater swim, jump in, catching and throwing

Lesson Four

Purpose: Running speed and coordination

Introduction: north-south-east-west, kicking on side of pool, sliding in on tummy

Swimming: kick with board, speedboat, freestyle arms, back kick with board, back stroke arms

Games: underwater swim, jump in, catching and throwing

Lesson Five

Purpose: Balance and coordination

Introduction: stretching, bunny hops

Swimming: kick board. speedboat, introduction of noodle, balancing with noodle, one leg balance, hop one leg, arm actions- swim one arm

Games: one leg balance, hop one leg

Lesson Six

Purpose: Balance and coordination

Introduction: stretching, bunny hops, simple tag

Swimming: kick board. speedboat, introduction of noodle, balancing with noodle, floating on tummy and back, pony ride, arm actions- swim one arm, one arm breathing

Games: chair in water- jump off chair, gym mats

Lesson Seven

Purpose: Strength and coordination

Introduction: stretching, jump in pool and getting out

Swimming: kicking with board, speed boat, speed boat with arms, pushing noodle, underwater swim, butterfly wiggle on back, float with noodle

Games: water-running relays, dolphin dives

Lesson Eight

Purpose: Strength and coordination

Introduction: stretching, jump in pool and getting out

Swimming: kicking with board, speed boat, speed boat with arms, pushing noodle, moving forward with arms, moving forward with legs, underwater swim, butterfly wiggle on back,

Games: water-running relays, one-leg races, dolphin dives

Lesson Nine

Purpose: Visual-motor control and balance

Introduction: stretching, bunny hops, diving through hula-hoops

Swimming: kick board (unassisted) to instructor, swim to instructor, pool noodle balance,

Games: swim to objects and pick it up, north-south-east-west

Lesson Ten

Purpose: Visual-motor control and balance

Introduction: stretching, bunny hops, diving through hula-hoops

Swimming: kick board (unassisted) to instructor, swim to instructor, pool noodle balance

Games: swim to objects and pick it up, north-south-east-west, throw at target (ball)

Lesson Eleven

Purpose: Coordination and dexterity

Introduction: stretching, tug of war, crazy circle (ball)

Swimming: kicking with board, swim with 3-5 arms, swim one arm (on side)

Games: dive through hula hoops, intro to dive, crawl on mats

Lesson Twelve

Purpose: Coordination and dexterity

Introduction: stretching, tug of war, crazy circle (ball)

Swimming: kicking with board, swim with 3-5 arms, swim one arm (on side), swim length of pool

Games: dive through hula hoops, intro to dive, crawl on mats

Lesson Thirteen

Purpose: Balance and strength

Introduction: stretching, swim forward only using arms, swim forward only using legs, float on back (star float)

Swimming: butterfly wiggle, wiggle on back, pushing of from wall, froggy swim

Games: somersault in water, pony ride, adapted water polo

Lesson Fourteen

Purpose: Balance and strength

Introduction: stretching, swim forward only using arms, swim forward only using legs, float on back (star float)

Swimming: butterfly wiggle, wiggle on back, pushing of from wall, froggy swim, aqua man – as far as can

Games: somersault in water, pony ride, adapted water polo

Lesson Fifteen

Purpose: Coordination and speed

Introduction: stretching, piggy in the middle, ball race

Swimming: speed boat, speed boat with arms (3-5), kick on side (unassisted), kick with rhythm, froggy swim, back float with arms, wiggle and arms

Games: relays, water polo, diving and swim

Lesson Sixteen

Purpose: All skills combined

Swimming: Showing parents different swimming strokes learned throughout the programme

Games: shipwreck