THE EFFECT OF A SPORT STACKING INTERVENTION PROGRAMME ON FINE AND GROSS MOTOR SKILLS IN PRESCHOOL CHILDREN

By

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DECLARATION

I, Mr Bhavik Daya, (Student number: 212517247) declare that:

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2. This dissertation has not been submitted for any degree or examination at any other university.

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Abstract

Introduction

The lack of physical activity among children is alarming and has become a major health concern as children are not engaging in enough physical activity to assist in the growth and development of the child. The development of motor skills in children plays an important role in the level of physical activity children engage in. If a child cannot efficiently run, kick, jump, catch, etc., then the opportunities to participate in sport and other physical activities will become limited because they will not have the necessary skills to do so. Fine motor skills are just as important as gross motor skills and are necessary for the development of basic self-help skills. Activities like sport stacking is believed to improve hand eye coordination, reaction time and motor proficiency.

Aim

The aim of this study was to investigate the effects of a five-week sport stacking intervention programme on fine and gross motor skills in preschool children.

Methods

The study was a quasi-experimental non-equivalent controls design with a pre- and post-intervention assessment. The sample selection was a convenient sample of 40 participants between the ages of four and six years. The Bruininks-Oseretsky Test of Motor Proficiency, second edition (BOT-2) was used to assess fine and gross motor skills. The data collected in this study was subjected to various statistical procedures. All the data was analysed by a computerised statistical procedure (SPSS Version 19) and descriptive (means and standard deviations) and inferential (paired t-tests and independent t-tests) statistics were used to test significant differences pre- and post- intervention with $p \leq 0.05$.

Results

Results demonstrated that the intervention group significantly improved in several fine and gross motor areas. Paired samples t-test for the intervention group showed significant differences for five items assessed (copying a star, transfer of pennies, dribbling a ball – alternating hands, sit-ups and one legged stationary hop). Independent samples t-test showed significant differences for transfer of pennies and dribbling a ball - alternating hands. Analysis of covariance showed significant differences in copying a star, transfer of pennies, tapping feet and fingers – same side synchronised, dribbling a ball – alternating hands and one-legged stationary hop.

Conclusion

A sport stacking intervention programme is a suitable method to improve fine and gross motor skills in preschool children.

Key words

Sport Stacking, Fine Motor Skills, Gross Motor Skills

CHAPTER ONE

1 Introduction

Sport stacking, also known as cup stacking or speed stacking originated during the 1980s in Southern California in the United States of America (USA) (Speedstacks, 2013.)

Sport stacking is defined as an individual and team sport that involves participants to use both hands to stack cups in a pre determined sequence to make a pyramid ("up stacking") and then return the cups back into stacks ("down stacking) (Speedstacks, 2016). Sport stacking also requires the individual to cross their hands across their body's midline (Uhrich, 2005).

Sport stacking initially involved stacking paper cups but due to its fragile nature, it was changed to plastic cups (Udermann & Murray, 2006). Through educational programmes in the USA, sport stacking gained international recognition in several countries such as Australia, Canada, Germany, Japan, Scandinavia and the United Kingdom (Udermann & Murray, 2006).

Physical inactivity is defined as doing none or very limited physical activity at work, home, school and transport to and from places (Micklesfield et al., 2014). Sedentary behaviour is defined as behaviours such as watching television and playing on the computer that have minimal physical movements and little energy expenditure - typically less than or equal to 1.5 Metabolic equivalent tasks (METs) (Tremblay et al., 2010). Murray et al. (2007) showed that sport stacking has an energy expenditure of 3.1 METs, which is similar to performing other physical activities that include bowling, archery and volleyball. Therefore, sport stacking can be classified as a moderate to vigorous physical activity.

Studies have shown that physical activity in children can provide numerous health benefits and that the more physical activity a child engages in, the greater the health benefits for that child. Additionally, results from numerous experimental studies have found that even moderate amounts of physical activity can have enormous health benefits in obese children (Janssen & LeBlanc, 2010). However, although one can participate in moderate to vigorous physical activity, sedentary behaviours can still increase ones risk of adiposity (Júdice et al., 2017).

The rate of obesity in young South African children has reached alarming concerns and approximately 73% of young South African children between the ages of four and five spend their time engaged in sedentary behaviours (Jones et al., 2014). Jones et al. (2014) showed that preschool intervention programmes that aim to promote physical activity and reduce sedentary behaviour could reduce the obesity rate in preschool children.

Physical activity in children and youth play an important role in the prevention of overweight and obesity as well as other noncommunicable diseases later in life (Uys et al., 2016). Physical inactivity is on the rise among both children and adolescents, with numerous studies in high-income countries showing an increase in both overweight and obesity amongst the population (Micklesfied et al., 2014).

Movement is crucial for a child's physical, cognitive as well as social development, but is often overlooked as it's such a natural part of life (Cools et al., 2009). Movement can be classified as fine and gross motor skills. Fine motor skills refer to the coordination of the small muscle groups in the hands to operate tools such as pencils, scissors and crayons accurately (Smith, 2003). Gross motor skills refer to the use of the whole body to perform large movements such as running, hopping, jumping, catching, etc. (de Witt, 2009). Gross motor skills are required to move, stabilise and control the body as well as objects when exploring the environment and well-developed gross motor skills will help an individual to function more efficiently later in life. Fine motor skills are just as important as gross motor skills and are necessary for the development of basic self-help skills (Cools et al., 2009).

Fine motor skills gradually develop through each developmental stage of a child's life and will keep on developing with age, practice, as well as playing sports and playing musical instruments (Meggitt, 2006). From the age of four, the child will start to fold pieces of paper, thread approximately twelve beads, begins to cut using a scissors, and enjoys playing with big blocks and dough making complex constructions. Between the ages of five and six, the child's fine muscle coordination becomes more refined and they can copy shapes such as circles and squares, draw pictures that are more recognisable and will use their hands more than their arms when catching objects (de Witt, 2009). Placing pegs into a peg board (Case-Smith et al., 1998), colouring and tracing of shapes and letters as well as using modelling clay to form letters are activities that can be used to improve fine motor skills (Lust & Donica, 2011).

Gross motor skills also develop through each developmental stage of a child's life but the development of the gross motor movements precedes that of the fine motor skills (de Witt, 2009). Between the ages of four and five, the child begins to run fast, run up and down stairs, can walk in a straight line, starts to climb trees and can ride a tricycle. At age five, the child can catch a ball, kick a ball while running, climb fences and begins to dress and undress themselves. At age six, the child becomes very adventurous and can jump over a rope using both feet and will start to run and skip on the jungle gym. Gross motor skills can be improved by performing various exercises such as balancing on a balance beam, push-ups, catching a beanbag, balancing on a balance board, hand stands, crawling on hands and knees (Vidoni et al., 2014) as well as side to side jumping and barefoot forward balancing (Donath et al., 2014).

Sport stacking improves hand eye coordination, reaction time and motor proficiency. Udermann et al. (2004) found that sport stacking improved hand eye coordination and reaction time in second grade students. Hart et al. (2005) assessed the influence of sport stacking on hand-eye coordination in 103 first, third and fourth grade students. The students showed significant improvements in one of the three hand-eye coordination measures. Furthermore, sport stacking has also shown to improve motor proficiency in children with developmental disorders (de Milander et al., 2014).

However, there is limited research on the benefits of sport stacking on fine and gross motor skills among preschool children. Physical inactivity and childhood obesity is on the rise and participation in physical activity has shown to improve motor efficiency in children as young as four years of age, thus highlighting the importance of practicing and improving motor skills from a young age (Livonen et al., 2013).

1.1 Aim

The aim of this study was to examine the effects of a five-week sport stacking intervention programme on the fine and gross motor skills in preschool children.

1.2 Objectives

To assess the fine motor skills (fine motor precision, fine motor integration and manual dexterity) of preschool children pre- and post-intervention.

To assess the gross motor skills (bilateral coordination, balance, upper limb coordination, strength, speed and agility) of preschool children pre- and post-intervention.

1.3 Hypotheses

1.3.1 Hypothesis

A sport stacking intervention programme will improve fine and gross motor skills in preschool children.

1.3.2 Null Hypothesis

A sport stacking intervention programme will not improve fine and gross motor skills in preschool children.

1.4 Significance of Study

This study could possibly provide a basis for further research to build upon in areas of physical activity, gross motor skills and fine motor skills in preschool children. This study could also provide a way of developing interventions and physical activity programmes that can assist in the development and improvement of fine and gross motor skills in preschool children.

1.5 Definition of Terms

Agility: The ability to stop, start or change direction of movement while maintaining balance or control of that movement (Coulson & Archer, 2009).

Balance: The ability to maintain an individuals centre of gravity over their base of support (Manske, 2006).

Bilateral coordination: The ability to use both sides of the body at the same time and in a coordinated manner (Molineux, 2017).

Body mass index (BMI): BMI is calculated by dividing body weight in kilograms by height in meters squared to determine an individuals weight relative to their height (Baechle & Earle, 2008).

Bruininks-Oseretsky Test of Motor Proficiency (BOTMP): Tools used to assess fine and gross motor skills in individuals (Carmosino et al., 2014).

Bruininks-Oseretsky Test of Motor Proficiency, second edition (BOT-2): A review of the BOTMP and is used to assess fine and gross motor skills in individuals (Carmosino et al., 2014).

Button frame: A wooden frame with material stretched on opposite edges. The material is cut down the middle and buttons have been attached, allowing the children to unbutton and button the material together (Montessoriworld, 2017).

Developmental coordination disorder (DCD): A neuro-developmental disorder and is responsible for causing impairment in motor coordination maturation (Polatajko & Cantin, 2006).

Fine motor integration: Assesses visual–motor skills when an individual copies different shapes (Lust & Donica, 2011).

Fine motor precision: Is associated with bilateral hand skills and accuracy when performing activities such as folding paper, and colouring (Lust & Donica, 2011).

Fine motor skills: Refer to the coordination of the small muscle groups in the hands to operate tools such as pencils, scissors and crayons accurately (Smith, 2003).

Gross motor skills: Use of the whole body to perform large movements such as running, hopping, jumping and catching (de Witt, 2009).

Knobbed cylinders: Four wooden blocks each containing ten cylinders. The cylinders vary in size and the child must remove the cylinders and place them back into the correct hole in the wooden block holding the cylinder by the knob (Montessoriworld, 2017).

Knobless cylinders: Four sets of wooden cylinders corresponding in size to the cylinders of set 1, 2, 3, and 4 of the solid knobbed cylinders in the cylinder blocks. Children choose a set and build a tower using the cylinders from that set (Montessoriworld, 2017).

Manual dexterity: Ability to use both coordinated hand and finger movements to hold and manoeuvre items (Kreutzer et al., 2011).

Metabolic equivalent tasks (METs): Stands for metabolic equivalent tasks and 1 MET is equal to 3.5ml of oxygen per kilogram of bodyweight per minute (Baechle & Earle, 2008).

Muscular strength: The ability to move a load against resistance (Bizley, 2002).

Obese: Having a BMI of greater than or equal to 30 (Baechle & Earle, 2008).

Overweight: Having a BMI of 25 to 29.9 (Baechle & Earle, 2008).

Physical inactivity: Doing none or very limited physical activity at work, home, school and transport to and from places (Micklesfield et al., 2014).

Pink tower: Ten solid wooden cubes varying in size from 1 cubic centimeter to 1 cubic decimeter. The child builds a tower with the biggest block at the bottom and smallest block at the top. (Montessoriworld, 2017).

Sedentary behaviour: Behaviours such as watching television and playing on the computer that have minimal physical movements and little energy expenditure - typically less than or equal to 1.5 METs (Tremblay et al., 2010).

Speed: Distance divided by time and can also refer to movement of the body when performing certain activities such as kicking or throwing a ball (Schwellnus, 2008).

Sport stacking: Sport stacking is defined as an individual and team sport that involves participants to use both hands to stack cups in a pre determined sequence to make a pyramid ("up stacking") and then return the cups back into stacks ("down stacking) (Speedstacks, 2016.)

Upper limb coordination: Coordinated movements that use certain patterns of temporal and spatial variability (Rodrigues et al., 2017).

1.6 Abbreviations

ACSM: American College of Sports Medicine

ANCOVA: Analysis of Covariance

BOTMP: Bruininks-Oseretsky Test of Motor Proficiency

BOTMP-SF: Bruininks-Oseretsky Test of Motor Proficiency-Short Form

BOT-2: Bruininks-Oseretsky Test of Motor Proficiency, second edition

DCD: Developmental Coordination Disorder

FASD: Fetal Alcohol Spectrum Disorders

HWT – GSS: Handwriting Without Tears – Get Set for School (HWT – GSS)

METs: Metabolic Equivalent Tasks

USA: United States of America

1.7 Conclusion

This study examined the effect of a five week sport stacking intervention programme on fine and gross motor skills in preschool children. The fine and gross motor skills which will were assessed were fine motor precision, fine motor integration, manual dexterity, bilateral coordination, balance, upper limb coordination, strength and running, speed and agility. This study aimed to potentially fill the gap in the literature and provide a way of developing interventions and physical activity programmes that can assist in the development and improvement of fine and gross motor skills in preschool children.

1.8 Structure of the dissertation

The dissertation will be presented as a full dissertation for a Master in Sports Science. The dissertation is presented as follows:

Chapter One: Introduction

Chapter Two: Literature Review

Chapter Three: Methodology

Chapter Four: Results and Discussion

Chapter Five: Conclusion

A manuscript (Appendix 7) will be submitted to the Journal of Perceptual and Motor Skills (eISSN: 1558688X; ISSN: 00315125).

CHAPTER TWO

2 Literature review

2. 1 Introduction

Sport stacking is a unique and interesting field of study. Sport stacking focuses on both entertainment as well as improving motor functioning in individuals. The literature on this topic is limited and the literature on sport stacking and preschool children is even more limited.

The literature review will comprise of the following sections:

Section A: Fine motor skills including fine motor precision, fine motor integration and manual dexterity, and the development of fine motor skills

Section B: Gross motor skills including bilateral coordination, balance, upper limb coordination, running speed and agility and strength, and the development of gross motor skills.

Section C: Developmental coordination disorder, including childhood obesity, sedentary behaviour and physical inactivity.

Section D: The Bruininks-Oseretsky Test of Motor Proficiency

Section E: The benefits of participation in sport stacking

Section A

2.2 Fine Motor Skills

Fine motor skills refer to the coordination of the small muscle groups in the hands to operate tools such as pencils, scissors and crayons accurately (Smith, 2003). The frontal lobe of the brain contains the primary motor area of the cortex and is associated with the finer movements of the muscles in the body (de Witt, 2009). Motor skills are actions a person engages in when interacting with objects and the environment (Park, 2015). Motor skill development in children can be influenced by several factors such as parents creating an environment that promotes motor skill development, engaging and interacting with children during play time and providing toys that improve motor functioning (Freitas et al., 2013). Academic performance can be affected by fine motor development (Peters et al., 2010) as fine motor skills are one of the components that play a role in a child's handwriting ability (Hammerschmidt & Sudsawad, 2004).

According to Case-Smith (1996), occupational therapists help improve fine motor skills in preschool children that have motor delays and motor impairments and have developed techniques that aim to increase fine motor skills development in children. The occupational therapist will try to improve play skills and enhance self-care function by focusing primarily on hand-eye coordination and manipulation.

A study by Case-Smith (1996) examined the fine motor skill and functional performance when occupational therapy was included in the educational programme of preschool children (n=26) in the United States of America. The study also aimed to investigate relationships among fine motor skills and functional performance in self-care, mobility and social function of children who received occupational therapy weekly. Fine motor skills (in-hand manipulation, tool use, hand-eye coordination, grasping strength, functional performance in self-care, mobility and social function) were assessed at the start and end of the school year. Results found that the raw and scaled scores showed improvements in all of the skill areas assessed.

A study by Katz (2005) was conducted to determine school readiness in 24 children across three Grade R classes in Cape Town, South Africa. The children were assessed on classroom performance (literacy, numeracy and conceptual formation), fine motor skills, visual perception and the ability to combine fine motor skills and visual perception. The results of the study indicated that most of the children had difficulty in most of the areas assessed. Similar findings were also found in a study conducted by Pretorius and Naude (2002) who assessed 30 preschool children and found significant deficits in fine motor skills and various cognitive skills.

Fine motor precision is associated with bilateral hand skills and accuracy when performing activities such as folding paper, and colouring (Lust & Donica, 2011). The effectiveness of a handwriting readiness programme on participants from Head Start was conducted by Lust & Donica (2011). Head Start is an initiative for low-income children that aims to promote school readiness. A two-group, non randomised controlled trial using a pre-test – post-test design was conducted with one preschool classroom being the control group that performed only the Head Start curriculum and the other classroom performing the Head Start curriculum with the Handwriting Without Tears – Get Set for School (HWT – GSS) curriculum. HWT – GSS is a programme that was designed to assist in the development of prewriting skills needed for Kindergarten. Post-test results found that significant improvements were made in the experimental group compared to the control group in the areas of pre writing, readiness for kindergarten and fine motor skills. Results from the subtest fine motor precision found that the post-test scores were significantly higher in the experimental group ($M \pm SD$: 8.47 ± 4.31 with $p = 0.045$) and demonstrated a medium treatment effect ($d = 0.74$).

Fine motor integration assesses visual–motor skills when an individual copies different shapes (Lust & Donica, 2011). A study to examine the effects of occupational therapy on visual motor skills in preschool children was conducted by Dankert et al. (2003). The study used a quasi-experimental, two-factor mixed design. Twelve preschool children with developmental delays received individual occupational therapy as well as group occupational therapy for 30 minutes a session per week was compared to two control groups. One control group comprised of 16 students without disabilities that received group occupational therapy for 30 minutes per week and the other control group comprised of 15 students without disabilities that received no occupational therapy. The results of the study showed that the experimental group significantly improved in their visual motor skills and developed skills much quicker than the control groups. The study concluded that interventions such as occupational therapy could improve visual motor skills in preschool children. The study showed that post-test scores were significantly higher in the experimental group for fine motor integration (M ± SD's = 12.00 ± 5.37 with $p = 0.021$) and showed a large treatment effect ($d = 0.87$).

Manual dexterity is defined as the ability to use both coordinated hand and finger movements to hold and manoeuvre items (Kreutzer et al., 2011). A study by Tortella et al. (2016) assessed the effects of structured and unstructured activities on motor competence in five-year-old children at playground Primo Sport 0246 in Italy. This playground was designed to enhance the gross motor skills of preschool children. The intervention group comprised of 71 children from various kindergartens that came to the park once a week for ten weeks and performed 30 minutes of free play and 30 minutes performing structured activities. Before and after the ten visits, the children performed nine tests to assess their motor skill levels. The control group comprised of 39 children from various kindergartens that did not come to the park. The results of the study showed no significant improvements were made in fine motor skills (which includes manual dexterity), as the programme in the playground focused on gross motor skills and no training or opportunities were given to enhance the development of fine motor skills.

2.3 Development of Fine Motor Skills

Fine motor skills gradually develop through each developmental stage of a child's life and will keep on developing with age, practice, as well as playing sports and playing musical instruments (Meggitt, 2006). From birth, involuntary reflexes characterise the first motor skills. Between two and five months, the child will begin to develop hand-eye coordination and will start to reach for and grasp objects (de Witt, 2009). From seven to twelve months, the child will start to grasp objects with the palm of their hands and start to feed themselves with finger foods. Between 13 and 24 months, the child will use their thumb and fore finger to pick up small objects, they will hold a small cup and drink out of it, begin to eat by themselves, throw objects, build a tower of two blocks and will start to pack objects into and out of a box. Between the ages of two and three, the child will be able to place a row of blocks on the ground, build a tower of seven blocks, open a door, play in water and sand, paint with a big brush and will start to undress themselves. Between the age of three and four, the child will start to draw horizontal lines and circles on paper using pencils or crayons, can thread six beads, build a tower using ten blocks and can wash their hands and face. From the age of four, the child will start to fold pieces of paper, thread approximately twelve beads, begins to cut using a scissors, enjoys playing with big blocks and dough making complex constructions. From the ages of five and six, the child's fine muscle coordination becomes more refined and they can copy shapes such as circles and squares, draw pictures that are more recognisable and will use their hands more than their arms when catching objects.

Section B

2.4 Gross Motor Skills

The premotor area is located in the frontal lobe of the brain, and is associated with larger movement patterns of the body that involve the bigger muscle groups (de Witt, 2009). Gross motor skills refer to the use of the whole body to perform large movements such as running, hopping, jumping and catching. Preschool is the period where a child makes fast and noticeable changes in child development. It's particularly during these years where a child makes noticeable improvements in their motor skills. It is therefore important to provide the child with enough opportunity to perform and practice numerous motor activities that will enhance their gross motor skills (Shala, 2009). Determining the quality of movement involved in the performance of motor skills particularly gross motor skills is important in determining the development of motor skills in children (Burton & Rodgerson, 2001). The assessment of gross motor skills in preschool children is important, however challenging (Williams et al., 2009).

du Toit & Pienaar (2002), examined the current level of gross motor development in South African preschool children in Potchefstroom. The study involved 462 children between the ages of three and six and they were tested on eight motor tasks (hopping, one leg balance, jumping jacks, standing long jump, skipping, throwing, balance walk and catching) The results of the study showed that the tests for throwing, balance walk and catching between the three to five year olds were lower than the normative data and that the results for the six year olds showed that they scored below the normative data for all the tests except for the standing long jump.

A study to examine the effects of a creative movement programme on gross motor skills in preschool children was conducted by Wang (2004). Participants were 60 preschool children between the ages of three and five. The experimental group performed the creative movement programme twice a week for 30 minutes per session. The control group performed only unstructured free play. The results of the study found that the experimental group scored significantly higher ($p < 0.05$) than the control group in gross motor skills.

Khalaj and Amri (2013) conducted a study to examine the gross motor skill development of obese children. Eighty participants between the ages of four and six were recruited in the study with 40 being obese children and 40 being normal-weight children. The test of gross motor development second edition was used to assess gross motor skills. The results of a one-way analysis of variance showed that there was a significant difference ($p = 0.000$) in gross motor quotient between the obese children and normal-weight children. The study concluded that obese children had poorer gross motor skill performance than the normal-weight children.

Bilateral coordination is the ability to use both sides of the body at the same time and in a coordinated manner (Molineux, 2017). A study to determine the effectiveness of a movement programme designed by preschool teachers was conducted by Vidoni et al. (2014). The study consisted of 33 preschool children and their motor skills were assessed using the BOT-2 test. Fifteen children were in the control group and 18 children were assigned to the intervention group. The intervention group participated in a daily 30-

minute structured physical activity programme for 11 weeks. The control group performed unstructured physical activity both in the classroom and in the playground. The results for jumping in place – same side synchronised showed that 14 children from the control and 17 children from the intervention group showed improvement. Where as tapping feet and fingers – same side synchronised found that nine children in the control group and 17 children in the intervention group showed improvement.

Balance is defined as having the ability to maintain an individuals centre of gravity over their base of support (Manske, 2006). A study to examine how effective activity cards are in preschool children was conducted by Donath et al. (2014). Two hundred and fourteen preschool children participated in the study with both the control and intervention group comprising of 107 children. The intervention group performed the KIDZ-Box® physical activity intervention programme which is specifically designed for preschool children. The intervention group were instructed to train daily for 15 minutes over seven months for agility, balance, endurance and jump performance. The results of the study for balance showed that balance did not significantly improve.

Defining upper limb coordination is difficult as there is a lack of agreement regarding its definition. Upper limb coordination is generally described as coordinated movements that use certain patterns of temporal and spatial variability (Rodrigues et al., 2017). An Iranian study assessed the effect of physical and sports activity programme on preschool children (Kordi et al., 2012). The study was a quasi-experimental study and 147 preschool children from five different schools participated in the study. The study was conducted over ten weeks and the aims of the study were to improve locomotor skills and object control skills. Object control skills included catching and dribbling as an item for assessment. The results of the study showed that the intervention programme improved all components of both locomotor and object control skills ($p < 0.001$).

Speed can be defined as distance divided by time and can also refer to movement of the body when performing certain activities such as kicking or throwing a ball (Schwellnus, 2008). Agility is the ability to stop, start or change direction of movement while maintaining balance or control of that movement (Coulson & Archer, 2009). A study by

Alpert et al. (1990) examined the effects of daily aerobic exercise for eight weeks on preschool children between the ages of three and five. The control and intervention group both consisted of 12 children each with the control group performing free play whilst the intervention group performed aerobic exercises. The results of the study showed that agility performance of the intervention group increased.

Strength is difficult to define, as there are many forms of strength and each have a different meaning for different functions. For the purpose of this study, muscular strength is used and muscular strength is defined as the ability to move a load against resistance (Bizley, 2002). Strength and agility skills of Grade One learners in the North West Province were assessed by Coetzee & Kemp, (2015). The study consisted of 816 participants and the results showed that 613 participants received average scores for strength and only 77 children were in the below average rating for strength.

2.5 Development of Gross Motor Skills

Gross motor skills also develop through each developmental stage of a child's life but the development of the gross motor movements precedes that of the fine motor skills (de Witt, 2009). From birth, the child will lie in the same position they are placed in, but can turn their heads to one side (Meggitt, 2006). Between three and six months, the child will begin to keep their head centralised when lying in a supine position, will be able to lift both their head and chest in a prone position using their forearms as support and will begin to kick using both their legs. At ten months, the child will begin to crawl and from 13 to 21 months the child will progress from standing by themselves to walking on their own to finally being able to walk backwards (de Witt, 2009). Between the age of two and three, the child will start to run, climb stairs, master the forward roll, jump using both feet and will start playing on the jungle gym. From the age of three to four, the child will begin to tip toe, can stand on one leg for six seconds, cross arms and legs when in a seated position and can throw a ball without losing their balance. Between the ages of four and five, the child begins to run fast, run up and down stairs, can walk in a straight line, starts to climb trees and can ride a tricycle. At age five, the child can kick a ball while running, catch a ball, begins to master different skills, climbs fences and begins to dress and undress themselves. At age six, the child becomes very adventurous and can jump over a rope using both feet and will start to run and skip on the jungle gym.

Section C

2.6 Childhood Obesity

An individual is considered overweight if they have a body mass index (BMI) of 25 to 29.9 where as an individual is considered obese if they have a BMI of greater than or equal to 30 (Baechle & Earle, 2008). Childhood over-nourishment (overweight and obesity) is increasing rapidly among South African children and has now become a public health concern (Mchiza & Maunder, 2013). Childhood over-nourishment has reached alarming concerns as there are approximately 22 million children under the age of five that are overweight worldwide (Deckelbaum & Williams, 2001). Over the last two to three decades, the number of children and adolescents that are overweight has doubled in the United States alone.

The increase in childhood over-nourishment has been observed world wide from preschool children to adolescence (Deckelbaum & Williams, 2001). These increases have affected all racial groups, however some racial groups have been greater affected than others. There are approximately 8% of preschool children between the ages of four and five that are overweight in the United States of America, however South Africa is one of a number of countries with a higher percentage of overweight children than the United States. Strategies to prevent obesity focus on nutritional and physical activity changes in children and adolescents who are associated with a BMI that is normal or above normal. Strategies to treat obesity focus on children and adolescents what are either overweight or obese (Nowicka & Flodmark 2008).

A Japanese study found that approximately one-third of children who are obese, remain obese through adulthood (Kotani et al., 1997). According to Whitaker et al. (1997) the risk of obesity occurring in adulthood was higher in obese and non-obese children if at least one of the parents were overweight. Childhood obesity is linked to numerous risk factors that individuals can experience at a later stage in their lives such as heart disease and numerous chronic diseases such as hyperlipidaemia, hyperinsulinaemia, hypertension as well as atherosclerosis (Cole et al., 2000). There has been a lot of progress made in heart disease and cancer treatment, but not a lot of progress has been made in the treatment of obesity (Baechle & Earle, 2008). Results from numerous studies have suggested that elevated levels of an individuals BMI during childhood can be a predictor for an individual being overweight in the future (Deckelbaum and Williams, 2001). According to Goran (2001), results across four studies showed that the chances of an individual becoming overweight at the age of 35 for children with a BMI between the 85th and 95th percentiles increased, as the individual got older.

A recent study in South Africa to inform intervention strategies to optimise body composition in South African preschool children was conducted by Draper et al. (2017). Data was recorded in both urban and rural areas and weight status, physical activity and motor skills were assessed with 341 children between the ages of three and six, and 55 teachers and parents were involved in focus groups. The results of the study showed there was a concern for overweight and obesity in low-income urban settings, however the physical activity and gross motor skills that were assessed were of no concern across both urban and rural settings.

2.7 Sedentary Behaviour And Physical Inactivity

Physical inactivity is defined as doing none or very limited physical activity at work, home, school and transport to and from places (Micklesfield et al., 2014). Preschool children are highly physically active and studies have found that children between the ages of three and five are more physically active than older children (Pate et al., 2008). Measuring the physical activity levels of preschool children is difficult as they perform a lot of the physical activity in short bursts (Bailey et al., 1995). Direct observation of the child is one way of determining the physical activity level of the child and this allows observation without reliance on the child's compliance (Brown, 2006).

Physical inactivity is on the rise among both children and adolescents, with numerous studies in high-income countries showing an increase in both overweight and obesity amongst the population. Physical activity in children and youth play an important role in the prevention of overweight and obesity as well as other noncommunicable diseases later in life (Uys et al., 2016). Physical activity is important not only for growth and development of the child but also for the development and enhancement of social cohesion, social inclusion and cognitive functioning (Ekelund et al., 2012). Parents and the home environment have a crucial role in the behaviours and beliefs children have of physical activity (Cislak et al., 2011). Parental participation in physical activity can have a positive influence on childhood participation in physical activity due to observational learning (Pugliese & Tinsley, 2007).

Sedentary behaviour is defined as certain behaviours (watching television, sitting, reading, working or playing on the computer) that have minimal physical movements and little energy expenditure, typically less than or equal to 1.5 METs (Tremblay et al., 2010). A MET is an abbreviation for metabolic equivalent tasks and one MET is equal to 3.5ml of oxygen per kilogram of bodyweight per minute (Baechle & Earle, 2008). Being involved in sedentary behaviours can still increase the risk of adiposity in individuals even if the individuals are often involved in moderate to vigorous physical activity (Júdice et al., 2014). Schary et al. (2012), provided evidence that parents can provide support that encourages physical activity among preschool children. Kremers et al. (2003) suggested that parents have an influence on children's diets and parents can also have an influence on the value and importance of a child being involved in physical activity (Hennessy et al., 2010). The effects parents have on childhood sedentary behaviours is limited, thus Schary et al. (2012) attempted to investigate parenting styles associated with sedentary behaviours in preschool children. They speculate that parent influences can play a role in reducing sedentary behaviours such as watching television, however more research is needed on this topic.

According to a South African study conducted with adolescents, 54.3% of adolescents have physical education lessons on their school timetable, and only 52.8% actually participate in vigorous activity during lessons (Mciza et al., 2007). Physical activity during childhood plays an important role when becoming an adult, thus highlighting the importance of addressing the need for physical activity among children and youth.

The literature on gross motor skills, sedentary behaviour and physical activity among South African children is very limited, however there is one observational study in Cape Town that included preschool children from various income settings, found that 73% of preschool children spent their time engaged in sedentary behaviour and 86% of their time were spent indoors (Uys et al., 2016). A study in the North West Province that involved six year olds from both rural and urban settings found that the children's gross motor skills do not appear to be a problem, however the amount of time the children spent participating in sedentary behaviours and indoors, were areas of concern.

Boreham and Riddoch (2001) believed that even though children are generally active throughout the day, they are exposed daily to numerous opportunities and environments that lead to them being involved in sedentary behaviours. Sedentary behaviours in childhood can lead to numerous health risks in adulthood including a risk of becoming overweight, poor fitness levels as well as increase cholesterol levels (Hancox et al., 2004).

In an effort to improve the levels of physical activity in children, a study was performed in Auckland, New Zealand where chairs and desks were removed and replaced with standing workstations (Hinckson et al., 2013). Hinckson et al. (2013), conducted a study with 30 grade three and four learners, with 23 participants in the intervention group and seven participants in the control group. Participants in the intervention group were provided with standing workstations where as the participants in the control group continued using their normal sitting desks. Participants in the intervention group were very enthusiastic about their standing workstations and spoke very highly about their standing workstations. Teachers at the school also praised the standing workstations. The results of the study showed that the participants in the intervention group sat less, stood longer and performed fewer transitions from sitting to standing than the participants in the control group. The study concluded that standing workstations appear to reduce sedentariness and can be incorporated into school classrooms.

Being involved in regular exercise can have a protective effect on an individuals bones and this is recognizable throughout life and can also reduce the risk of fractures later in life (Gunter et al., 2012). Participating in physical activity from as young as the age of five, can result in improved bone mineralisation and this can also improve bone mineral density when becoming a young adult (Botha et al., 2013).

Children and adolescents need to be involved in at least 60 minutes of moderate to vigorous intensity physical activity daily as recommended by the American College of Sports Medicine (Nigg, 2013). The 60 minutes of physical activity is in addition to the activity that the children perform throughout the day through sport, transport, games and play. Children below the age of one should perform floor play (Crawling and tummy time) several times daily (Botha et al., 2013). Preschool children should engage in three hours of physical activity daily and this can be performed in short intervals of performing physical activities (Botha et al., 2013).

2.8 Developmental Coordination Disorder

Developmental coordination disorder (DCD) is defined as a neuro-developmental disorder and is responsible for causing impairment in motor coordination maturation (Polatajko & Cantin, 2006). The amount of children that are at risk for neurodevelopmental disability or with established neurodevelopmental disability is enormous (Msall, 2005). Clinicians often overlook DCD, however there is evidence to suggest that the problems associated with DCD can have a negative effect on the child as they experience difficulties in both planning and organizing themselves (Kirby & Sugden, 2007). DCD affects 5% of school aged children and in addition to having difficulties with motor function, these children may experience difficulty in learning, behaviour and psychosocial adjustment (Richardson & Montgomery, 2005). These difficulties have an impact on the child at home and at school (Kirby & Sugden, 2007).

Children with DCD do not perform as much physical activity as other children as they feel they do not have the same physical capabilities as the other children (Cairney et al., 2005). The lack of participation in physical activity increases the risk of children with DCD becoming overweight or obese as a lack of participation in physical activity is an important factor that contributes to an individual becoming overweight or obese (Cairney et al., 2005).

A study by Cairney et al. (2005) was conducted to examine the relationship between DCD and overweight and obesity in children. A cross sectional investigation of 578 children between grades four to eight across five elementary schools was conducted. Developmental coordination disorder was evaluated using the BOTMP-SF. Body fat percentage and BMI were used to measure overweight and obesity. The results of the study with bivariate analysis showed that children with DCD were likely to be more overweight and obese that children without DCD when percentage body fat was used. No significant differences were found in overweight and obesity between children with DCD and without DCD. However, children with DCD did have a higher percentage of overweight and obese children (Cairney et al., 2005)

Section D

2.9 Bruininks-Oseretsky Test Of Motor Proficiency

The Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) and its review, the Bruininks-Oseretsky Test of Motor Proficiency, second edition (BOT-2) are tools used to assess fine and gross motor skills in individuals (Carmosino et al., 2014). The BOT-2 is based on the Oseretsky test, which was designed in 1903 by Oseretsky in Russia (Doll, 1946). The Oseretsky test consisted of five subtest categories which were divided into general static coordination, dynamic coordination of the hands, general dynamic coordination, motor speed and simultaneous voluntary movements (Lam, 2011). The Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) was developed in 1978 and it was hoped that this new test would measure gross and fine motor skills individually (Bruininks, 1978). The BOT-2 is the current and latest version of the BOTMP (Bruininks

& Bruininks 2005).

The complete BOT-2 has 53 items that are divided into 8 subtests. The subtests are fine motor precision (seven items), fine motor integration (eight items), manual dexterity (five items), bilateral coordination (seven items), balance (nine items), running, speed and agility (five items), upper limb coordination (seven items) and strength (five items) (Cools et al., 2009).

The short form consists of 14 items from the eight subtests (Table 2.1) (Fransen et al., 2014).

Table 2.1: Items assessed in the BOT-2 short form

Subtest	Item
Fine motor precision	Drawing a line through crooked paths
	Folding paper
Fine motor integration	Copying a square
	Copying a star
Manual dexterity	Transfer of pennies
Bilateral coordination	Jumping in place – same side synchronised
	Tapping feet and fingers – same side synchronised
Balance	Walking forward on a line
	Standing on one leg on a balance beam with eyes open
Running, speed and agility	One-legged stationary hop
Upper limb coordination	Dropping and catching a ball - both hands
	Dribbling a ball - alternating hands
Strength	Knee push-ups
	Sit-ups

The score an individual receives can be the number of points, correct activities performed or time in seconds for each item (Matson, 2015) and a high correlation has been found between the two BOT-2 forms (Cools et al., 2009).

A study conducted by Cairney et al. (2009), to assess the validity of the BOTMP-SF showed that the BOTMP-SF appears to be a suitable alternative to case identification when clinical assessment with the movement assessment battery for children is not feasible.

An Australian study to determine if the BOT-2 short form is a reliable assessment tool for children living in remote Australian Aboriginal communities was conducted by Lucas et al. (2013). Thirty children between the ages of seven and nine from the Lililwan Project (The first population-based study to determine Fetal Alcohol Spectrum Disorders (FASD) prevalence in Australia) participated in the study. Inter-rater and test-retest reliability was conducted using the BOT-2 short Form. The results from the study found that the inter-rater reliability for the BOT-2 short form indicated excellent reliability and the results from the test-retest reliability for the BOT-2 short form indicated fair to good reliability. The study concluded that the BOT-2 short form could be used in remote Australian Aboriginal communities as the BOT-2 short form has acceptable reliability.

Section E

2.10 Benefits Of Sport Stacking

Sport stacking is said to improve hand eye coordination, reaction time and motor proficiency. According to Udermann et al. (2004), sport stacking improved hand eye coordination and reaction time in second grade students and this is important because hand eye coordination and reaction time play an important role in many human movements. The children were divided into a control group and intervention group. The intervention group were required to perform sport stacking for 20-30 minutes per day, four times a week for five weeks. The control group were required to continue with their normal physical education classes. The results of the study showed that sport stacking significantly improved the children's quickness and reaction time.

Another study by Hart et al. (2005) assessed the influence of sport stacking on hand-eye coordination in 103 first, third and fourth grade students. The students participated in a sport stacking unit for three weeks and hand-eye coordination was measured in three different aspects. The students performed sport stacking for a total of five hours and the results showed significant changes in one of the three hand-eye coordination measures.

Conn (2004) assessed the effect of sport stacking on reaction time, movement time and ambidexterity in 82 fourth grade students. The students performed a five-week programme that combined sport stacking with scooter and volleyball skills. The students stacked for a total of four hours and 40 minutes. The results of the study found that there was a significant difference in movement time but no differences in reaction time.

Sport stacking can improve motor proficiency in children with developmental coordination disorder (de Milander et al., 2014). Eighteen children between the ages of six and seven participated in this study. The sport stacking intervention was an eight-week programme that consisted of three sessions per week that lasted 30 minutes per session. The results of the study indicate that sport stacking can be used to improve motor proficiency in children with developmental disorders.

Zareian and Delavarian (2014) assessed the effect of sport stacking on fine motor proficiency in children with Down syndrome. Fifteen students participated in this study and their fine motor skills were assessed using the short form of the Bruininks-Oseretsky test. The students performed sport stacking for eight weeks and subjects performed individual and group exercise of sport stacking for two sessions per week for 30 minutes. The results of the study showed that sport stacking improved the fine motor skills in children with Down syndrome and the study concluded that sport stacking could improve motor problems in children with Down syndrome.

The effect of sport stacking on auditory and visual attention in 32 Grade three children was assessed. The participants were randomly assigned to either the sport stacking or arts/crafts group with each group consisting of 16 participants. The participants performed sport stacking or arts/crafts for three weeks, which was followed by a three week wash-out period, after which a cross-over (sport stacking group now performed arts/crafts and the arts/crafts group performed sport stacking) was implemented and the intervention programme was repeated. Results showed that sport stacking could lead to improvements in high demand function and fine motor regulation (Mortimer et al., 2011).

Park et al. (2015) attempted to investigate the effects of sport stacking on senior adults in Korea. The results of the study showed that sport stacking was enjoyed by 88.2% of participants, 79.4% reported a positive change in health and 94.4% stated that they would participate in future sport stacking programmes.

A criticism of sport stacking is that individuals engage in little physical activity whilst performing sport stacking, however a study by Murray et al. (2007) states that sport stacking has an energy expenditure of 3.1 METs. Thirty-seven subjects participated in this study and expired respiratory gases as well as the heart rate of participants were monitored for ten minutes. The results of the study showed that sport stacking has an energy expenditure of 3.1 METs, which is similar to performing other physical activities that include bowling, archery and volleyball. The authors of this study also believe that sport stacking, due to its role in the improvement of skills such as hand eye coordination and reaction time, should be incorporated into the physical educational curriculum.

CHAPTER THREE

3 Methodology

3.1 Research design

The study was a quasi-experimental non-equivalent controls design with a pre- and post-intervention assessment. A quasi-experimental non-equivalent controls design is when the experimenter tries to incorporate the design to real-world settings, while still controlling threats to internal validity (Thomas et al., 2011).

3.2 Population and sample

The population comprised of preschool children in Durban North. The sample selection was a convenient sample of 40 participants between the ages of four and six years. The grade 0 and 00 classes were recruited to participate in the study. Grade 0 is also known as Grade R and grade 00 is the year before grade 0. The school has two grade 00 and two grade 0 classes. One of the grade 0 and one of the grade 00 classes were randomly assigned as the intervention groups (n=20) and the other grade 0 and grade 00 classes were the control groups (n=20).

The sample adhered to the following inclusion criteria.

Inclusion criteria

- Aged between four (turning four in the year 2016) and six years old.
- No prior exposure to sport stacking

Exclusion criteria

- Not physically abled to participate in moderate to vigorous physical activity

3.3 Testing procedures and protocol

Procedure

Gatekeeper's permission was requested and given by the principal's at Ocean View Montessori School (Appendix 1). Ethical clearance from the Biomedical Research Ethics Committee (BFC389/16) (Appendix 2) was obtained and the study commenced. A call for participants occurred at the school via a meeting with parents. The researcher presented the study to the parents. The parents/guardians of participants that adhered to the inclusion criteria received an information sheet and were required to complete the parental consent form (Appendix 3).

Protocol

Pre-Intervention:

Baseline measures of all participants, included height, weight and calculating their body mass index (BMI) were performed. Fine and gross motor skills were assessed one week prior to the intervention using the Bruininks-Oseretsky Test of Motor Proficiency, second edition (BOT-2 short form). Fine and gross motor skills of participant's were assessed on the same day that the participant's height, weight and BMI were determined.

Participant's height was taken first, followed by their weight and finally their BMI was calculated. After which, participant's performed their fine and gross motor skills using the BOT-2 short form. Participant's performed the BOT-2 short form in the following order (Figure 3.1):

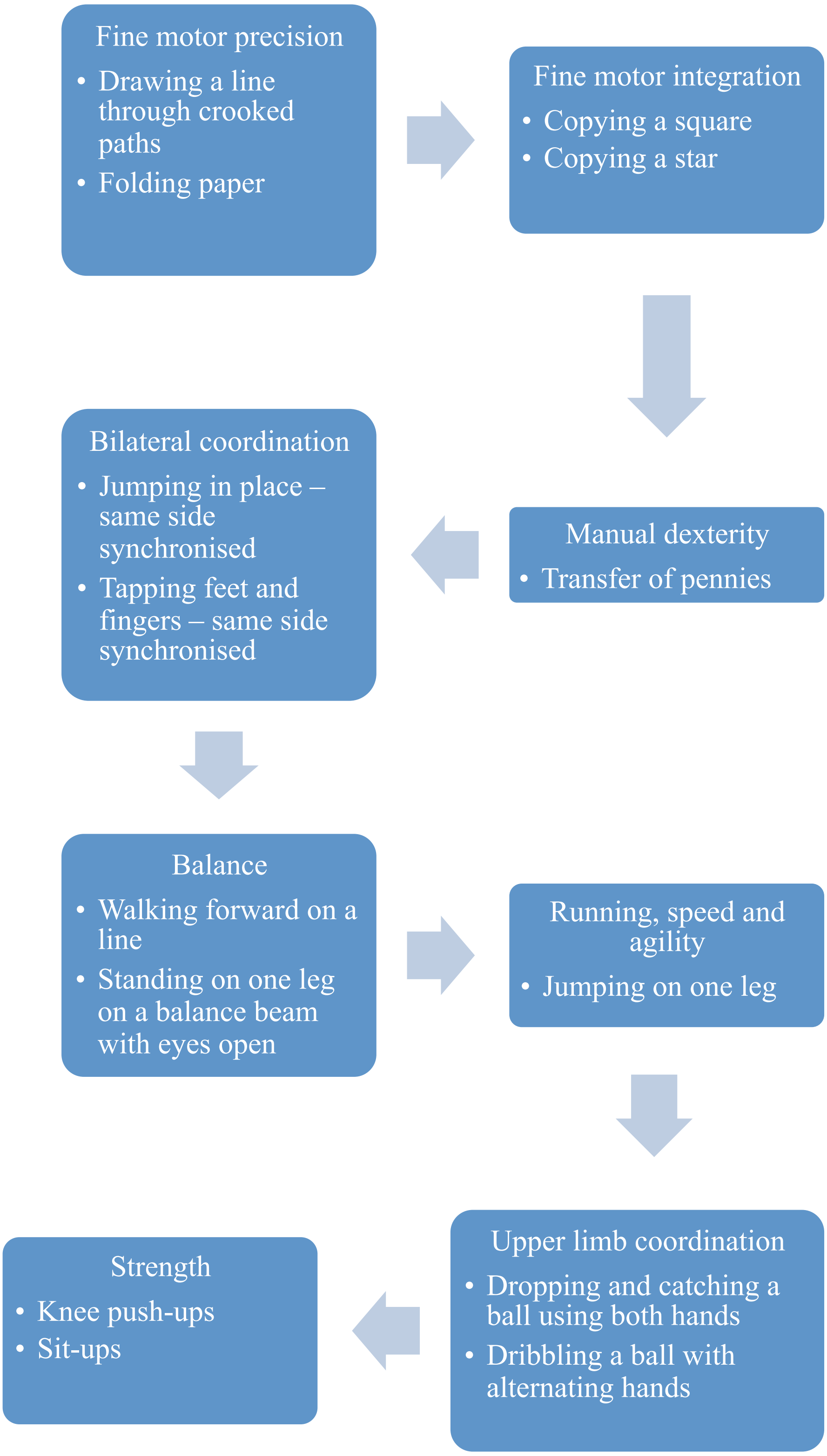

Figure 3.1: Testing order for the BOT-2 short form

Thereafter, participants assigned to the intervention group were shown how to stack the cups in the correct sequence, using the correct technique. This familiarisation period (Table 3.1) was conducted over five days.

Table 3.1: Familiarisation period

Day	**Activities**
1	• Introduce teachers to sport stacking and show them an instructional video. • Show teachers the 3-3-3 stack sequence, the 3-6-3 sequence and the 6-6 stack sequence by individual instruction.
2	• Introduce children to sport stacking and show them an instructional video. • Show them the 3-3-3 stack sequence by group instruction as well as individual instruction if needed.
3	• Recap of day 1. • Children practice the 3-3-3 stack sequence. • Introduce children to the 3-6-3 stack sequence by group instruction as well as individual instruction if needed.
4	• Recap of day 1 and 2. • Children practice both the 3-3-3 and 3-6-3 stack sequence. • Introduce children to the 6-6 stack sequence by group instruction as well as individual instruction if needed.
5	• Recap of day 1-3. • Children practice the 3-3-3, 3-6-3 and 6-6 stack sequence.

Once all baseline data was collected (Appendix 4) and the familiarisation period was completed, the intervention group began with the sport stacking intervention programme, while the control group continued with daily activities as per norm. Activities included both fine and gross motor activities during their school day. Fine motor activities included colouring, painting, playing with blocks and lego, and threading beads. Gross motor activities included walking, running, jumping and playing on the jungle gym. Selected children participated in extra mural activities such as swimming, ballet, monkeynastics and little kickers (soccer).

Intervention:

The sport stacking intervention programme consisted of two sessions (Day one – fine motor activities and day two – gross motor activities a week for five weeks. Each session lasted between 30-45 minutes. Table 3.2 describes the intervention activities.

Table: 3.2: Sport stacking intervention programme

WEEK	DAY 1 ACTIVITIES	DAY 2 ACTIVITIES
1	• Sport stacking • Opening and closing locks with keys • Placing beads onto a soap pad using tweezers	• Sport stacking • Balancing on one leg with eye's open and closed • Hop scotch
2	• Sport stacking • Threading of both large and small beads • Button frame	• Sport stacking • Walking in a straight line with a bean bag on the heads of participants • Throwing a ball/beanbag through a hoola hoop
3	• Sport stacking • Transferring water into ice cube trays using a pipette. • Pink tower	• Sport stacking • Jumping on a springboard and catching a bean bag • Using a hoola hoop
4	• Sport stacking • Nuts and bolts • Tracing- Insets for design	• Sport stacking • Throwing a ball at objects • Walking on a balance beam
5	• Sport stacking • Knobbed/knobless cylinders • Picking up and placing of items into a correct container using a peg	• Sport stacking • Walking on stilt buckets • Bouncing a ball in a straight line

Post-Intervention

All participants were re-assessed on their baseline measures.

The control group were given the opportunity to participate in the intervention at the end of the study.

3.4 Data collection

The researcher, a qualified exercise scientist and sports coach administered all pre- and post-tests as well as conducted the intervention programme. The researcher was assisted by the teachers who organised and supervised the children during the study.

3.5 Instrumentation

Body Mass Index (BMI)

Height was measured using a stadiometer (a steel ruler or measuring tape securely stuck to a wall). Participants were required to take off their shoes, stood with their feet together and hands at their side. Their body was in contact with the wall. Weight was measured using a scale. The scale was calibrated before testing. The participants were asked to stand on the scale without shoes on. Body mass index was calculated by dividing body weight in kilograms by height in meters squared to determine the individuals weight relative to their height (Whaley et al., 2006). All results were recorded.

Speed Stacks

Speed stacks were used for the intervention programme (Figure 3.2).

Figure: 3.2 Cups used for sport stacking (Speed Stacks, 2016)

Fine And Gross Motor Assessment

The Bruininks-Oseretsky Test of Motor Proficiency, second edition (BOT-2 short form) was used to assess the fine and gross motor skills of the participants (Figure 3.3). The fine motor skills that were assessed were fine motor precision, fine motor integration and manual dexterity. The gross motor skills that were assessed were bilateral coordination, balance, upper limb coordination, strength, speed and agility.

The BOT -2 short form (Table 3.3) consists of 14 items from the eight subtests (Fransen et al., 2014).

Table 3.3: BOT-2 short form subtests and items

Subtest	Item
Fine motor precision	Drawing a line through crooked paths
	Folding paper
Fine motor integration	Copying a square
	Copying a star
Manual dexterity	Transfer of pennies
Bilateral coordination	Jumping in place – same side synchronised
	Tapping feet and fingers – same side synchronised
Balance	Walking forward on a line
	Standing on one leg on a balance beam with eyes open
Running, speed and agility	One-legged stationary hop
Upper limb coordination	Dropping and catching a ball - both hands
	Dribbling a ball - alternating hands
Strength	Knee push-ups
	Sit-ups

The score participants received were either the number of points, correct activities performed or time in seconds for each item (Matson, 2015).

Figure: 3.3 BOT-2 short form kit (Pearson, 2016)

For subtest one (fine motor precision), the participants performed two activities, drawing lines through paths – crooked (Figure 3.4) and folding paper (Figure 3.5).

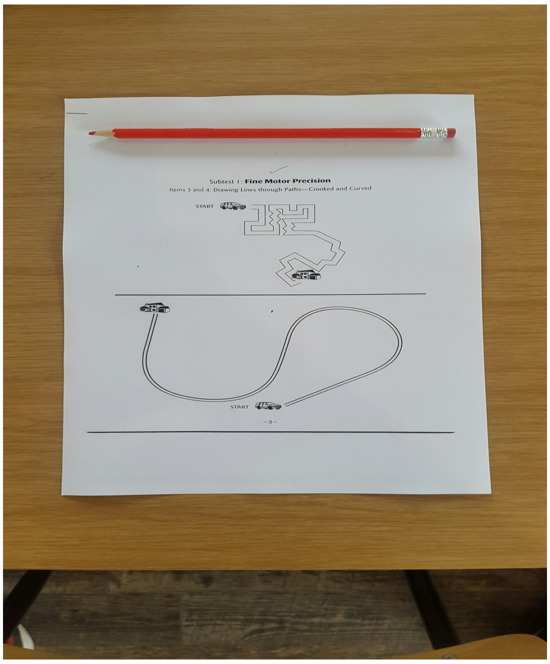

Figure: 3.4 Drawing lines thorough crooked paths

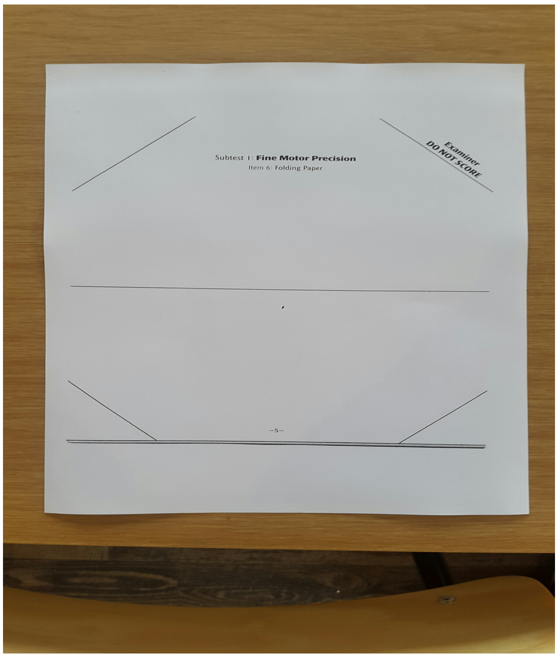

Figure: 3.5 Folding paper

The procedure for drawing lines through paths – crooked, required the participant to hold a red pencil in their preferred hand and they drew a line through the path from the car to the house. The score recorded was the number of errors the participant made. Errors were for the amount of times the participants went out the lines (Bruininks & Bruininks, 2005).

The procedure for folding paper required the participant to fold along a line in any order. The participants were first shown how to fold the corner of the paper labelled "Examiner" on its line and then the participants folded the remaining three corners along each line. To record the score, a straight-line overlay on the scoring transparency was placed on the page. Errors were for folds not on the folding line. The score the participant received was then recorded (Bruininks & Bruininks, 2005).

For subtest two (fine motor integration), the participants were required to copy a square (Figure 3.6) and a star (Figure 3.7). The procedure for both items required the participants to hold a red pencil in their preferred hand and they copied each shape as best as possible in the box provided. The score recorded was based on the basic shape, closure, edges, orientation and size of the shape the participants copied (Bruininks & Bruininks, 2005).

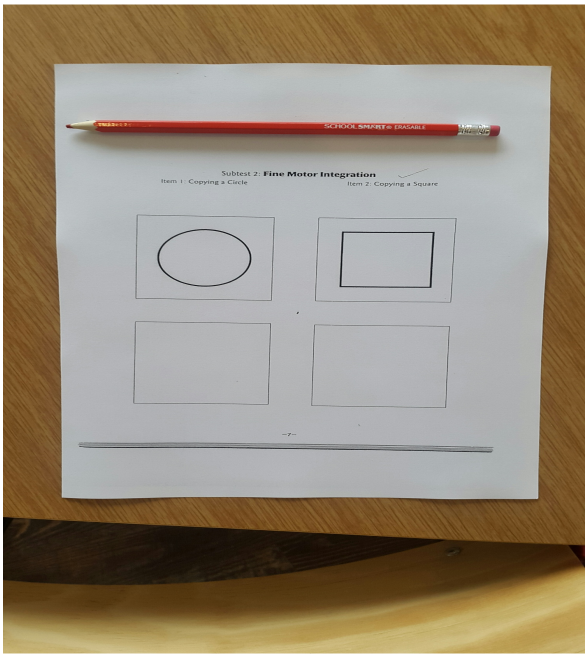

Figure: 3.6 Copying a square

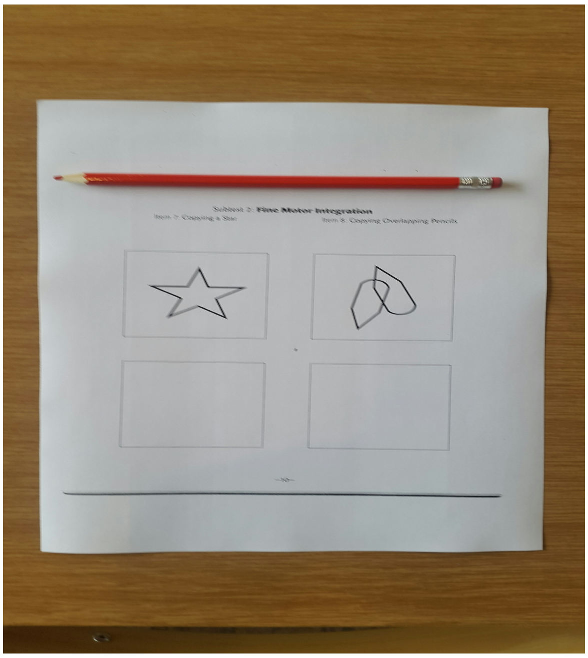

Figure: 3.7 Copying a star

For subtest three (manual dexterity), the participants transferred pennies from a penny pad into a box (Figure 3.8). The procedure required the participants to pick a penny using their preferred hand, transfer the penny to their non-preferred hand and place it into the box. The score recorded was the number of pennies placed into the box in 15 seconds (Bruininks & Bruininks, 2005).

Figure: 3.8 Transfer of pennies

For subtest four (bilateral coordination), the participants performed two activities, jumping in place – same side synchronised (Figure 3.9) and tapping feet and fingers – same sides synchronised (Figure 3.10).

Figure: 3.9 Jumping in place – same side synchronised

Figure: 3.10 Tapping feet and fingers – same side synchronised

The procedure for jumping in place – same sides synchronised, required the participant to stand with their preferred leg and arm on the same side forward and the other leg and arm to the back. The participants then jumped up and brought the non-preferred leg and arm on the same side forward, moving the other leg and arm back. The score recorded was the number of correct jumps (up to five) (Bruininks & Bruininks, 2005).

The procedure for tapping feet and fingers required the participant to sit at a table with their index fingers extended and other fingers tucked in. The participant then simultaneously tapped their foot and index finger on the same side of their body and then simultaneously tapped their foot and index finger on the other side of their body. The score recorded was the number of correct taps (up to ten) (Bruininks & Bruininks, 2005).

For subtest five (balance), the participants performed two activities, walking forward on a line (Figure 3.11) and standing on one leg on a balance beam – eyes open (Figure 3.12).

Figure: 3.11 Walking forward on a line

Figure: 3.12 Standing on one leg on a balance beam – eyes open

The procedure for walking forward on a line required the participant to stand with feet together, preferred foot on and parallel to the line with their hand on hips. The participants then walked forward placing feet on and parallel to the line with each step. The score recorded was the number of correct steeps (up to six) (Bruininks & Bruininks, 2005).

The procedure for standing on one leg on a balance beam – eyes open required the participant to stand with their preferred foot on the balance beam and non-preferred foot on the floor with hands on hips. The participant then raised their non-preferred leg behind themselves. The score recorded was the number of seconds that the participant maintained proper form (up to ten seconds) (Bruininks & Bruininks, 2005).

For subtest six (running, speed and agility), the participants performed a one-legged stationary hop (Figure 3.13). The procedure for the one-legged stationary hop required participants to stand with feet together and hands on hips. Participants raised their non-preferred leg behind themselves and hopped up and down on their preferred leg. The score recorded was the number of correct steps performed in 15 seconds (Bruininks & Bruininks, 2005).

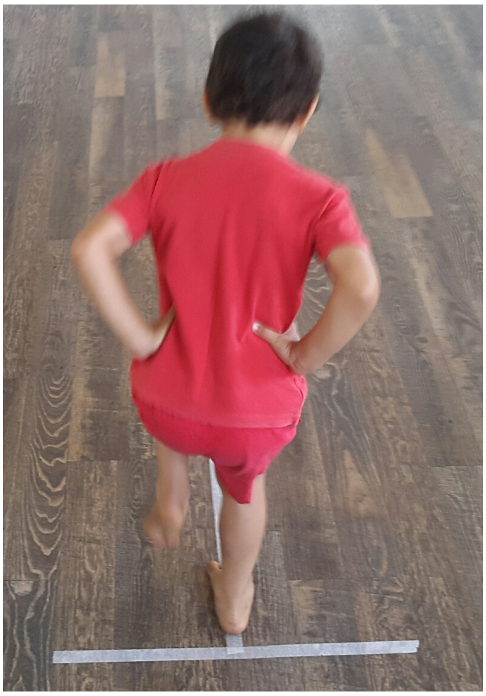

Figure: 3.13 One-legged stationary hop

For subtest seven (upper-limb coordination), participants performed two activities, dropping and catching a ball – both hands (Figure 3.14) and dribbling a ball – alternating hands (Figure 3.15).

Figure: 3.14 Dropping and catching a ball – both hands

Figure: 3.15 Dribbling a ball – alternating hands

The procedure for dropping and catching a ball – both hands, required participants to hold a tennis ball in both hands, drop the ball, and catch the ball after it bounced once on the floor. The score recorded was the number of correct catches (up to five) (Bruininks & Bruininks, 2005).

The procedure for dribbling a ball- alternating hands, required participants to hold a tennis ball in their preferred hand, drop the ball and then dribble the ball by alternating their hands with each dribble. The score recorded was the number of correct dribbles (up to ten) (Bruininks & Bruininks, 2005).

For subtest eight (Strength), participants performed two activities, knee push-ups (Figure 3.16) and sit-ups (Figure 3.17).

Figure: 3.16 Knee push-ups

The procedure for knee push-ups required participants to kneel down on the kneepad, lean forward and place hands on the floor. The participants crossed ankles and raised their feet off the floor. The participants performed knee push-ups by lowering themselves toward the floor and then pushing back up until their arms were straight. The score recorded was the number of correct knee push-ups completed in 30 seconds. Incorrect knee push-ups are when the participants back sags, or when the participant tilts their hips so their back is no longer straight (Bruininks & Bruininks, 2005).

Figure: 3.17 Sit ups

The procedure for sit-ups required participants to lie with their back on the floor, arms by their sides and palms down. Their knees were bent and they performed sit-ups by raising their head, shoulders and shoulder blades off the floor; reaching for their knees; and then lowering their body back to the floor. The score recorded was the number of completed sit-ups in 30 seconds. An incorrect sit up is when the participant pushes up from the floor using their elbows, uses clothing to bring themselves to their knees, feet are not flat on floor or if their shoulder blades don’t touch the floor before the next sit-up (Bruininks & Bruininks, 2005).

3.6 Ethical Considerations

Permission to conduct this study was granted by the Ethics committee of the University of .Kwa Zulu-Natal and the principal's of the school. Prior to the commencement of the study, all participants' parents were required to complete the parental consent form. Participation in this study was entirely voluntary and confidentiality and anonymity was maintained throughout the study.

3.7 Statistical Analysis

The data collected in this study was subjected to various statistical procedures. All the data was analysed by a computerised statistical procedure (SPSS Version 19) and descriptive (means and standard deviations) and inferential (paired t-tests and independent t-tests) statistics, analysis of covariance (ANCOVA) and effect sizes were used to test significant differences pre- and post-intervention with $p \leq 0.05$.

3.8 Conclusion

The methods stated in this chapter will attempt to answer the questions and objectives for this study. The following chapter focuses on the results obtained from the intervention and control group, pre- and post-intervention.

CHAPTER FOUR

4 Results and Discussion

4.1 Introduction

This chapter presents the results obtained from the cohort. There was a 100% compliance of 40 preschool children. Results will be presented according to the following headings: Demographics and sample distribution, Anthropometric data, and BOT-2 short form.

4.2 Demographics and sample distribution

The average age of the whole sample (n=40) was 5.2 years.

Figure 4.1 describes the sample distribution of the two classes.

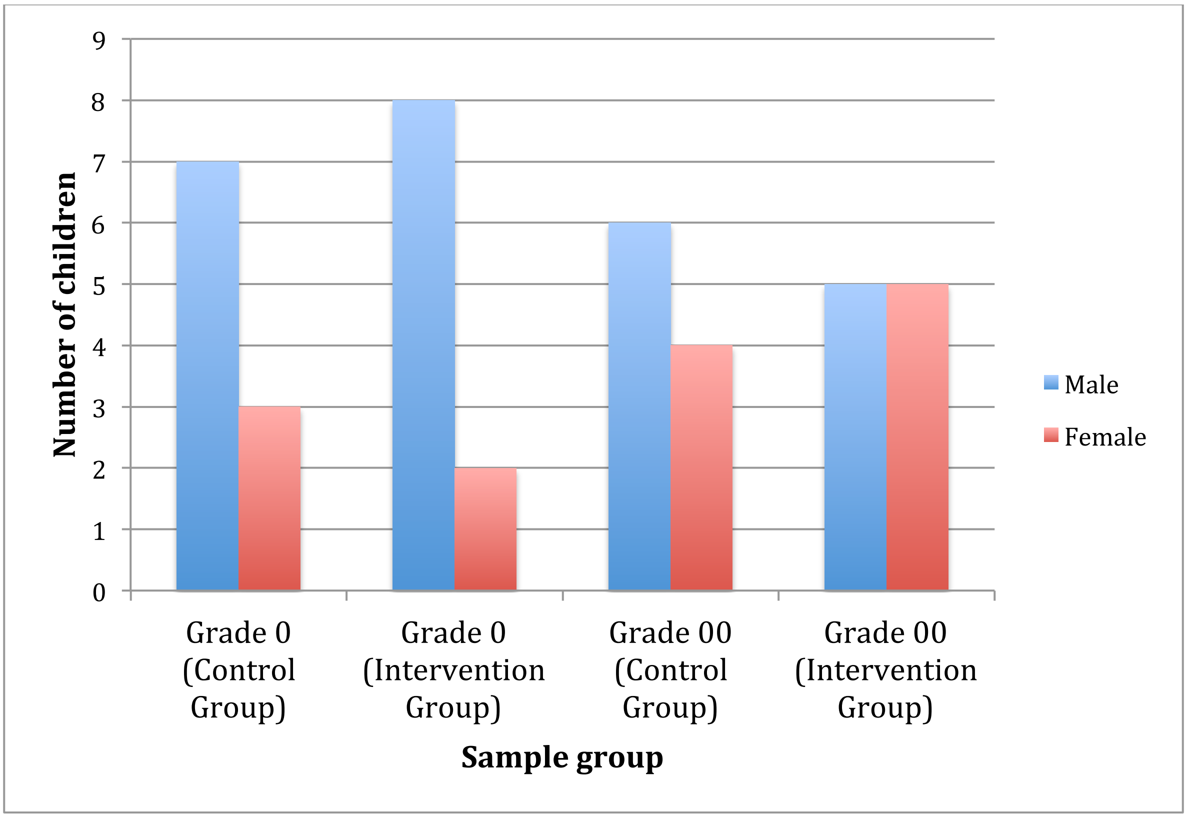

Figure 4.1: Sample distribution of participants according to gender.

In total, 26 males and 14 females participated in this study. The average age for participants in the intervention group was 5.3 (± 1.011) years old and the average age for participants in the control group was 5.1 (± 0.921) years old.

4.3 Anthropometric data

Table 4.1 shows the anthropometric data of the sample pre- and post-intervention. Participant's height, weight and Body Mass Index (BMI) were calculated.

Table 4.1: Anthropometric data of the sample (n=40) pre- and post-intervention.

	PRE - Height (m)	POST- Height (m)	PRE - Weight (kg)	POST - Weight (kg)	PRE – BMI (kg/m^2)	POST – BMI (kg/m^2)
Mean	1.14	1.14	21.30	21.38	16.36	16.41
Standard Deviation	± 0.08	± 0.08	± 3.38	± 3.35	± 1.54	± 1.55
Minimum	1.02	1.02	15	15	13.50	13.50
Maximum	1.30	1.31	30	30	19.00	19.30

4.4 BOT-2 short form tests

For each of the skills assessed, various statistical analyses were conducted. Refer to Appendix 6 for results for all skills assessed.

Firstly, the paired samples t-test (Table 4.2) was applied to test for significant differences pre- and post-intervention for the control and intervention groups.

Table 4.2: Results for paired samples t-test.

Test Item	Pre: Mean (SD)	Post: Mean (SD)	Significance (p)
Copying a star	2.05 (± 1.605)	2.70 (± 1.720)	0.012
Transfer of pennies	1.75 (± 0.851)	3.45 (± 1.050)	0.000
Dribbling a ball – alternating hands	2.90 (± 1.683)	3.50 (± 1.732)	0.019
Sit Ups	3.25 (± 1.372)	3.65 (± 1.089)	0.017
One-legged stationary hop	7.45 (± 1.761)	8.15 (± 1.22)	0.003

The paired samples t-test for the control group showed no significant differences for each of the items assessed. However, for the intervention group, significant differences for copying a star ($p = 0.012$); transfer of pennies ($p = 0.000$); dribbling a ball – alternating hands ($p = 0.019$); sit ups ($p = 0.017$); and one-legged stationary hop ($p = 0.003$) was evident.

Independent samples t-test (Table 4.3) were conducted to test for significant differences in the pre-scores and post-scores across the control and intervention groups.

Table 4.3: Results for independent samples t-test

Test Item	Pre: Mean (SD)	Post: Mean (SD)	Significance (p)
Transfer of pennies	Control: 2.00 (± 0.858)	Control: 2.25 (± 0.967)	0.001
	Intervention: 1.75 (± 0.851)	Intervention: 3.45 (± 1.050)	
Dribbling a ball – alternating hands	Control: 2.60 (± 1.392)	Control: 2.50 (± 1.357)	0.049
	Intervention: 2.90 (± 1.683)	Intervention: 3.50 (± 1.732)	

There were only two skills that showed significantly different scores for the two groups, i.e. post-transfer of pennies and post-dribbling a ball – alternating hands.

There was a significant difference in the post-score for the transfer of pennies across the two groups (p = 0.001). The score for the control group (M = 2.25, SD = ± 0.967) was significantly lower than the experimental group (M = 3.45, SD = ± 1.050).

There was also a significant difference in the post-score for dribbling a ball – alternating hands across the two groups (p = 0.049). The score for the control group (M = 2.50, SD = ± 1.357) was significantly lower than the experimental group (M = 3.50, SD = ±1.742).

Analysis of covariance (Table 4.4) were applied to test whether the intervention had a significant effect on the post-scores after correcting for the pre- scores.

Table 4.4: Results for analysis of covariance

Test Item	Significance (p)
Copying a star	0.039
Transfer of pennies	0.000
Tapping feet and fingers – same side synchronised	0.049
Dribbling a ball – alternating hands	0.006
One – legged stationary hop	0.001

Analysis of covariance showed no significant differences for the control group. Copying a star ($p = 0.039$); transfer of pennies ($p = 0.000$); tapping feet and fingers – same side synchronised ($p = 0.049$); dribbling a ball – alternating hands ($p = 0.006$) and the one – legged stationary hop ($p = 0.001$), showed significant improvements post- intervention.

The effect sizes were calculated for each skill for both groups separately. Table 4.5 shows the effect size and the classification of the effect size (small, medium or large) for both the control and intervention groups.

Table 4.5: Effect Sizes for control and intervention group

Item Assessed For Control Group	**Effect Size**	**Classification Of Effect Size**
Transfer of pennies	0.3	Small
Knee push-ups	0.2	Small
Item Assessed For Intervention Group	**Effect Size**	**Classification Of Effect Size**
Folding paper	0.2	Small
Copying a square	0.3	Small
Copying a star	0.4	Small
Transfer of pennies	1.8	Large
Tapping feet and fingers – same side synchronised	0.3	Small
Walking forward on a line	0.3	Small
Dribbling a ball - alternating hands	0.4	Small
Knee push-ups	0.2	Small
Sit ups	0.3	Small

One-legged stationary hop	0.5	Medium

According to Vacha-Haase & Thompson (2004), an effect size is classified using Cohens's *d.* An effect size with a Cohen's *d* value of 0.2 is regarded as a small effect. A medium effect size is classified with a Cohen's *d* value of 0.5 and a large effect size is classified with a Cohen's *d* value of 0.8.

The control group identified two items (transfer of pennies and knee push-ups) that resulted in a small effect.

The intervention group identified eight items (folding paper, copying a square, copying a star, tapping feet and fingers – same side synchronised, walking forward on a line, dribbling a ball - alternating hands, knee push-ups and sit-ups) resulting in a small effect. The one-legged stationary hop resulted in a medium effect and the transfer of pennies resulted in a large effect.

Discussion

4.5 Introduction

The aim of this study was to examine the effects of a sports stacking intervention programme on fine and gross motor skills in preschool children. The objectives of the study were to assess both fine and gross motor skills pre- and post-intervention. This chapter will focus on discussing the results obtained from the BOT-2 short form scores and will help answer the study's research question and objectives.

Fine and gross motor skills play an important role throughout a person's lifetime. Poor motor skills can result in limited opportunities for a child to participate in sport and other physical activities, as they will not have the necessary motor skills to perform these activities (Stodden et al., 2008). This will lead to physical inactivity and sedentary behaviours, which could lead to a child becoming overweight or obese (Uys et al., 2016).

Sport stacking requires the use of both hands to stack cups in a pre-determined sequence and then to return the cups back into stacks. The results from this study showed that the sport stacking intervention programme resulted in improvements in selected components of both fine and gross motor skills. Various statistical analyses showed significant differences in both fine and gross motor skills particularly in the areas of fine motor integration for copying a star (paired samples t-test: $p = 0.012$ and ANCOVA: $p = 0.039$) manual dexterity (paired samples t-test: $p = 0.000$, independent samples t-test: $p = 0.001$ and ANCOVA: $p = 0.000$), bilateral coordination for tapping feet and fingers – same side synchronised (ANCOVA: $p = 0.049$), upper limb coordination for dribbling a ball – alternating hands (paired samples t-test: $p = 0.019$, independent samples t-test: $p = 0.049$ and ANCOVA: $p = 0.006$), strength for sit-ups (paired samples t-test: $p = 0.017$) and running, speed and agility (paired samples t-tests: $p = 0.003$ and ANCOVA: $p = 0.001$).

The results of this study indicate that the bilateral movement between both the left and right hands appears to have resulted in improvements in manual dexterity and certain components of both bilateral coordination and upper limb coordination of the intervention group post-intervention.

4.6 Manual Dexterity, Bilateral Coordination And Upper Limb Coordination

The results for manual dexterity showed that the intervention group improved significantly (paired samples t-test: p = 0.000, independent samples t-test: p = 0.001 and ANCOVA: p = 0.000) when all tests were applied to test for significant differences pre and post-intervention. Therefore, sport stacking could have contributed to the significant improvement of manual dexterity as sport stacking involves the use of both hands. On the contrary, results from Tortella et al. (2016) who examined the effects of structured and unstructured activities on motor competence in five-year-old children, found no significant improvements for manual dexterity post-intervention for the intervention group. Activities performed included rope ladder, climbing rope, hanging bar, gymnastic rings, climbing net, monkey bars, balance beam, balance logs, balance elastic beam and balance platforms. However, it is important to note that their programme focused on gross motor skills and no opportunities were given to enhance the development of fine motor skills, which could have played a major role in improving manual dexterity. Li, et al. (2011) also found improvements, although not significant in manual dexterity for Grade two children that participated in a 12-week sport stacking intervention programme. The pre-test time of 67.43 seconds improved to 61.07 seconds (post-test). Manual dexterity was measured using a grooved pegboard where as this study used the transfer of pennies to measure manual dexterity. The mean scores for the intervention group in the current study showed that manual dexterity improved from 1.75 (pre-test) to 3.45 (post-test).

Zareian and Delavarian (2014) found significant differences in upper limb speed and dexterity in the areas of card sorting with the dominant hand (p = 0.000) and arranging beads around a string (p = 0.000) after eight weeks of sport stacking in the intervention group for children with Down syndrome. Significant differences (p = 0.0191) were also found in manual dexterity for children with Developmental coordination disorder who participated in a sport stacking intervention programme performed by De Milander et al.

(2014).

In the current study, the items assessed for bilateral coordination were jumping in place – same side synchronised and tapping feet and fingers – same side synchronised. Only tapping feet and fingers – same side synchronised ($p = 0.049$) showed significant improvement when ANCOVA was used to test for significance. This difference could be as a result of both hands being used when performing sport stacking. Similarly, Rhea et al. (2006) found that the intervention group, after performing sport stacking for five weeks, had a positive effect on bilateral coordination in sixth grade physical education students.

The tests performed for upper limb coordination were dropping and catching a ball - both hands and dribbling a ball - alternating hands. Dropping and catching a ball – both hands showed no significant differences however, significant improvements were made in dribbling a ball - alternating hands when all tests were applied to test for significant differences. Sport stacking could have had a direct effect on dribbling a ball – alternating hands as both hands are required when performing sport stacking and when dribbling a ball. Dribbling a ball also incorporates hand eye coordination and Li et al. (2011) measured hand eye coordination using a grooved pegboard, found improvement in hand eye coordination in the intervention group as the time for the photoelectric rotary pursuit tracking test improved from 9.22 seconds (pre-test) to 11.31 seconds (post-test).

Interestingly, the results for dropping and catching a ball after selective physical training in students with a learning disability by Rostami et al. (2015) showed significant differences being made for catching a tossed ball when the Freedman test was applied ($p = 0.00$) and when the Mann Whitney U test was applied ($p = 0.01$) to test for significance.

4.7 Fine Motor Integration, Strength, Speed And Agility

The fine and gross motor skill activities that were performed in conjunction with sport stacking appear to have made significant differences in certain areas of fine motor integration, strength and speed and agility.

The results from the study for fine motor integration found that the intervention group improved in both copying a star and copying a square with only copying a star showing a significant improvement. The average score for copying a square increased from 3.90 to 4.20 ($p = 0.209$) whereas the average score for copying a star significantly increased from 2.05 to 2.70 ($p = 0.012$). The pre-test results for copying a square were much higher than for copying a star which could indicate that copying a star was more difficult than copying a square. Hence, the inclusion of a movement skill programme into the preschool curriculum can improve children's fine motor integration. This is supported by Vidoni et al. (2014), as their study showed that post-test scores of 18 children that participated in the intervention programme, all 18 participants improved in copying a star, where as only 13 participants showed an improvement in copying a square. According to Lane (2005), a child should begin to draw a square at the age of four and it takes approximately two years of development for a child to progress from drawing a square to a vertical diamond. Given that the average age of the intervention group was 5.3 (± 1.011) years, the significant difference made in copying a star is justified.

The results for fine motor integration by Lust and Donica (2011) showed a significant improvement in fine motor integration ($p = 0.021$) in children between the ages of four and five. Their study's intervention programme focused on fine motor precision and fine motor integration skills which included activities such as body awareness skills, directional concepts, letter-play activities as well as colouring and tracing of capital letters and shapes, compared to the multiple fine motor skills focused on in this study.

Knee push-ups and sit-ups were tested for strength. Only sit-ups showed a significant difference between pre and post-test scores after the intervention programme when the paired samples t-test was applied to test for significance ($p = 0.017$). However, it is important to note that the intervention programme did not focus primarily on upper body strength and endurance. Significant differences made for sit-ups could be a direct result of involvement in extramural activities such as monkeynasticks, swimming, little kickers (soccer) and ballet. Vidoni et al. (2014) showed improvement being made in both sit-ups (18 out of 18 participants) and knee push-ups (16 out of 18 participants) in their 11-week structured physical activity intervention programme. Activities included push-ups, pencil rolls, crawling on hands and knees on the floor, hand-stands on mat against the wall, back lifts and somersaults on a mat could have resulted in strength improvements.

Results for running, speed and agility in the one-legged stationary hop showed significant differences when both the paired samples t test was applied to test for significance for the intervention group ($p = 0.003$) and when ANCOVA was used to assess for significance ($p = 0.001$). Activities in the intervention programme that included hopscotch and jumping on a springboard could have resulted in the significant improvements being made in running, speed and agility.

4.8 Fine Motor Precision And Balance

The two subtests for fine motor precision performed in this study were drawing a line through crooked paths and folding paper. The results of the study showed that the intervention programme had no significant effect on both drawing a line through crooked paths and folding paper. These results do not coincide with the results obtained from Donica et al. (2011) in which significant differences were found in the intervention group (M ± SD: 8.47 ± 4.31 with $p = 0.045$). The reasons for the significant improvements made in fine motor precision could be as a result of the study focusing primarily on fine motor precision and fine motor integration skills such as letter – play activities, colouring, tracing of capital letters and tracing of shapes whereas the current study's intervention programme focused on multiple fine motor activities and not just fine motor precision and fine motor integration skills. The short duration of this study compared to the long duration of their intervention programme (from October to March and consisted of three sessions a week), could have played a role in the improvements made in fine motor precision.

Another study by Zareian and Delavarian (2014) the assessed the effect of sport stacking on fine motor proficiency in children with Down syndrome found that significant differences were found in drawing lines through crooked paths ($p = 0.000$).

Walking forward on a line and standing on one leg on a balance beam with eyes open were the tests applied for balance. Both walking forward on a line and standing on one leg on a balance beam with eyes open showed no significant differences pre- and post-intervention. Balancing on one leg with eye's open and closed, hop scotch, walking in a straight line with a bean bag on head, walking on a balance beam and walking on stilt buckets were activities performed in the intervention programme for the intervention group which focussed on balance. The BOT-2 short form maximum score for walking forward on a line and standing on one leg on a balance beam with eyes open is four. The average score for the intervention group was 3.85 (pre-test) and 3.95 (post-test) for walking forward on a line and 3.30 (pre-test) and 3.30 (post-test) for standing on one leg on a balance beam with eyes open. The pre-test scores for both items assessed for balance show that the intervention group scores were high to begin with; hence no significant improvements being made as the pre-test scores left little room for improvement. The average score for both the pre- and post-test scores for the intervention group for standing on one leg on a balance beam with eyes open was 3.3 out of 4 which indicates that participants were able to balance for approximately 6.0-9.9 seconds. Additionally, a child at the age of five should be able to balance on one leg for more than eight seconds and be able to walk heel to toe backwards (Glascoe & Robertshaw., 2010).

CHAPTER FIVE

5 Conclusion, Recommendations and Limitations

This final chapter presents conclusions taking into consideration the study's objective. The objectives of the study were to assess fine motor skills and gross motor skills of preschool children pre- and post-intervention. Additionally, recommendations and limitations of the study will be presented.

5.1 Conclusion

This study investigated the effect of a five-week sport stacking intervention programme on both fine and gross motor skills in preschool children. In conclusion, the five-week sport stacking intervention programme produced greater improvements in selected areas fine and gross motor skills compared to the control group.

The objectives of the study were to assess fine motor skills and gross motor skills of preschool children pre and post-intervention. The sport stacking intervention significantly improved fine motor skills (fine motor integration and manual dexterity) and gross motor skills (bilateral coordination, upper limb coordination, strength and running, speed and agility).

Although the children in both groups participated in extramural activities (monkeynasticks, swimming, little kickers (soccer) and ballet), the control group showed no significant improvements in both fine and gross motor skills. Thus, the intervention programme can be directly associated with the significant improvements being made in both fine and gross motor skills.

In conclusion the sport stacking intervention programme produced greater improvements in both fine and gross motor skills particularly in the areas of fine motor integration, manual dexterity, bilateral coordination, upper limb coordination, strength and speed and agility. Thus, a sport tacking intervention programme is a suitable method to improve fine and gross motor skills in preschool children.

5.2 Recommendations

There is still a need for an intervention study that includes a larger sample size, includes all preschools and not just Montessori preschools and consists of an equal number of both male and female participants. Studies should also focus on including participants of the same age, as preschool children make rapid improvements in fine and gross motor skills at different ages. Similar studies should also be conducted in other provinces throughout South Africa. Further studies should also have a longer duration for the intervention programme and should have more activities for fine and gross motor skills. The researcher believes that good eating habits should be promoted at preschools to encourage preschool children to start eating healthy from a young age. In addition to extra mural activities, the researcher believes that physical activity programmes should be implemented at preschools.

5.3 Limitations of the study

This study had several limitations. Firstly, the number of participants in this study was small. Secondly, the number of males and females were unequal which may have had an effect on the results as more boys were enrolled at the school than girls. Thirdly, gender differences were not considered. Lastly, the study was conducted over five weeks and the benefits may only be short-term.

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6 Appendices

Appendix 1: Principal's Permission Letter

Principal's Permission Letter

Address:	Discipline of Biokinetics,
32 Oxford Drive	Exercise and Leisure Sciences
Durban	Westville Campus
4016	Durban

Project Title:

THE EFFECT OF A SPORT STACKING INTERVENTION PROGRAMME ON FINE AND GROSS MOTOR SKILLS IN PRESCHOOL CHILDREN

Dear Mrs. Cronje and Mrs. Lowry

As a Master of Sport Science student at the University of Kwa Zulu-Natal, I am involved in a research project for my Masters degree. This study is an experiment involving preschool children between the ages of 4-6, whom will be performing a sport stacking intervention programme twice a week for 5 weeks. Sport stacking requires an individual to stack cups up and down and involves speed and dexterity.

Should you and the participants' parents/guardians agree to their involvement in this project, the participants will be involved in a pre-test and post-test that will assess the participants BMI as well as their fine and gross motor skills. A sport stacking intervention programme that consists of sport stacking as well as fine and gross motor activities will be performed twice a week for five weeks for the intervention group where as the control group will continue with their daily school activities. The intervention programme will last for 45 minutes per session. This study will not interfere with the school's education programme and once ethical clearance has been granted by the Research Committee of the University of KwaZulu Natal, I will commence the study.

The proposed benefits include possible improvements in both fine and gross motor skills.

The proposed benefits include possible improvements in hand eye coordination, reaction time and motor proficiency.

Participants may decide not to take part in the project without any disadvantage to themselves of any kind. Participants may withdraw from participation in the project at any time and without any disadvantage to themselves of any kind. The data from both the pre- and post-test will be collected and analysed. Results of this study may be published but any data included will in no way be linked to any specific participant. Parents/Guardians may request a copy of the results of the project should they wish. At the end of the project any personal information will be destroyed immediately except that, as required by the University's research policy, any raw data on which the results of the project depend will be retained in secure storage for five years, after which it will be destroyed.

If there are any further questions or concerns, please feel free to contact me or my supervisor (Dr. Rowena Naidoo) at the University of KwaZulu Natal (Westville Campus) on the contact details below.

Many thanks for taking the time to read this and I hope to hear from you soon.

Yours faithfully

Bhavik Daya (researcher) Dr Rowena Naidoo (Supervisor)

Telephone Number- 072 946 3391

Email: bhavikdaya@gmail.com Email: naidoor3@ukzn.ac.za

______________________ ______________________

Signature of Principal (Mrs. Cronje) Date

______________________ ______________________

Signature of Principal (Mrs. Lowry) Date

Appendix 2: Ethical Clearance

UNIVERSITY OF KWAZULU-NATAL™
INYUVESI YAKWAZULU-NATALI

08 September 2016

Mr B Daya (212517247)
Discipline of Biokinetics, Exercise and Leisure
School of Health Sciences
bhavikdaya@gmail.com

Dear Mr Daya

Protocol: The effect of a sport stacking intervention on fine and gross motor skills in preschool children.
Degree: M-Sports Science
BREC reference number: BFC389/16

The Biomedical Research Ethics Committee (BREC) has considered the abovementioned application at a meeting held on 16 August 2016.

The conditions have been met and the study is given **full ethics approval** and may begin as from 08 September 2016.

This approval is valid for one year from **08 September 2016.** To ensure uninterrupted approval of this study beyond the approval expiry date, an application for recertification must be submitted to BREC on the appropriate BREC form **2-3** months before the expiry date.

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

Your acceptance of this approval denotes your compliance with South African National Research Ethics Guidelines (2015), South African National Good Clinical Practice Guidelines (2006) (if applicable) and with UKZN BREC ethics requirements as contained in the UKZN BREC Terms of Reference and Standard Operating Procedures, all available at http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx

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

Pg. 2/...

Biomedical Research Ethics Committee
Professor J Tsoka-Gwegweni (Chair)
Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Telephone: +27 (0) 31 260 2486 **Facsimile:** +27 (0) 31 260 4609 **Email:** brec@ukzn.ac.za
Website: http://research.ukzn.ac.za/Research-Ethics/Biomedical-Research-Ethics.aspx

Appendix 3: Parent/Guardian and Participant Information Sheet and Consent Form

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

Parent/Guardian and Participant Information Sheet and Consent Form

Project Title:

THE EFFECT OF A SPORT STACKING INTERVENTION PROGRAMME ON FINE AND GROSS MOTOR SKILLS IN PRESCHOOL CHILDREN

Dear Parent / Guardian

Thank you for showing an interest in this project. Please read this information sheet carefully before deciding whether or not you wish for your child to participate. If you decide to allow your child to participate, I thank you. If you decide not to allow your child to take part, there will be no disadvantage to your child of any kind and we thank you for considering our request.

The project is being undertaken as the requirement for a Masters degree in the discipline of Biokinetics, Exercise and Leisure Sciences at the University of KwaZulu-Natal.

The purpose of the study is to determine the effect of a five-week sport stacking intervention programme on fine and gross motor skills in preschool children. Sport stacking is defined as an individual and team sport that involves participants to use both hands to stack cups in a pre determined sequence to make a pyramid ("up stacking") and then return the cups back into stacks ("down stacking). Sport stacking not only focuses on the entertainment aspect, but also on the motor functioning aspect.

The participants needed are male and female preschool children. The participants must be between the ages of four and six, have no prior exposure to sport stacking and must be physically abled to participate in sport stacking.

Should you agree for your child to take part in this project, your child will be asked to participate in a five-week sport stacking programme. Participant's height and weight will be taken to determine their BMI (Body mass index) and their fine and gross motor skills will also be assessed using the Bruininks-Oseretsky Test of Motor Proficiency, second edition (BOT-2 short form) prior to and after the five-week sport stacking programme is complete. BMI is calculated by dividing body weight in kilograms by height in meters squared to determine an individuals weight relative to their height. The fine motor skills that will be assessed are fine motor precision, fine motor integration and manual dexterity. The gross motor skills that will be assessed are bilateral coordination, balance, upper limb coordination, strength, speed and agility.

There are minimal risks in this study, except maybe participants may feel fatigued or slight muscle soreness, which is a normal response to unaccustomed physical activity. However, the researcher will ensure that a proper warm-up and cool-down is performed by your child and that your child performs the activities at their own pace. The researcher is a qualified first aider and will be present during all testing and the sport stacking programme.

Benefits could include improved fine and gross motor functioning.

The proposed benefits of sport stacking include possible improvements in hand eye coordination, reaction time and motor proficiency.

The intervention will consist of a programme involving sport stacking, as well as fine and gross motor activities. The non-sport stacking participants (control group) will be required to continue with their daily school routine.

The purpose for the data being collected is to see the effect of the five-week sport stacking programme on fine and gross motor skills performance. Results of this project may be published but any data included will in no way be linked to any specific participant. As a benefit, you are most welcome to request a copy of your child's results and of the project should you wish. The data collected will be securely stored in such a way that only those mentioned above will be able to gain access to it. At the end of the project any personal information will be destroyed immediately except that, as required by the University's research policy, any raw data on which the results of the project depend will be retained in secure storage for five years, after which it will be destroyed.

Your child may withdraw from participation in the project at any time and without any disadvantage to your child of any kind.

There will be no compensation for participating in this study. However, all children will receive water bottles and refreshments after each session.

This study has been ethically reviewed and approved by the UKZN Biomedical research Ethics Committee (approval number BFC389/16).

In the event of any problems or concerns/questions you may contact the researcher or the UKZN Biomedical Research Ethics Committee, contact details as follows:

BIOMEDICAL RESEARCH ETHICS ADMINISTRATION

Research Office, Westville Campus

Govan Mbeki Building

PrivateBagX54001
Durban
4000

KwaZulu-Natal, SOUTH AFRICA

Tel: 27 31 2604769 - Fax: 27 31 2604609

Email: BREC@ukzn.ac.za

If you have any questions about the project, either now or in the future, please feel free to contact the researcher or the supervisor.

Bhavik Daya (Researcher)

Telephone Number- 072 946 3391

Email: bhavikdaya@gmail.com

Dr Rowena Naidoo (Supervisor)

Email: naidoor3@ukzn.ac.za

PARENTAL CONSENT:

I, ... have been informed about the study entitled “The Effect of A Sport Stacking Programme On Fine And Gross Motor Skills In Preschool Children” By Bhavik Daya.

I have read the Information Sheet concerning this project in which my child has been requested to participate in and understand what it is about. All my questions have been answered to my satisfaction. I understand that I am free to request further information at any stage.

I know that:

1. Participation in the project is entirely voluntary;
2. My child will be required to participate in a five week sport stacking intervention;
3. My child is free to withdraw from the project at any time without any disadvantage;
4. The data will be destroyed at the conclusion of the project but any raw data on which the results of the project depend will be retained in secure storage for five years, after which it will be destroyed;
5. The results of the project may be published but your child’s anonymity will be preserved.
6. There will be no remuneration or compensation for your child’s participation in this study.
7. I will receive a copy of this form.

If I have any questions or concerns about my child's rights as a study participant or if I am concerned about an aspect of the study or the researchers or in the event of any problems or concerns/questions you may contact the researcher or the UKZN Biomedical Research Ethics Committee, contact details as follows

BIOMEDICAL RESEARCH ETHICS ADMINISTRATION

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Bhavik Daya (Researcher)

Telephone Number- 072 946 3391

Email: bhavikdaya@gmail.com

Dr Rowena Naidoo (Supervisor)

Email: naidoor3@ukzn.ac.za

____________________ ____________________

Signature of Parent/Guardian **Date**

____________________ ____________________

Signature of Witness **Date**

Appendix 4: Baseline Data Collection Sheet

<u>Intervention Group</u>

Subject Number	Pre-Test			Post-Test		
	Height (m)	Weight (kg)	BMI	Height (m)	Weight (kg)	BMI

Control Group:

Subject Number	Pre-Test			Post-Test		
	Height (m)	Weight (kg)	BMI	Height (m)	Weight (kg)	BMI

Appendix 5: Fine and Gross Motor Skills Assessment

Subject Number:

Subtest	Item	Score
Fine Motor Precision	Drawing a line through crooked paths	
	Folding paper	
Fine Motor Integration	Copying a square	
	Copying a star	
Manual Dexterity	Transfer of pennies	
Bilateral Coordination	Jumping in place – same side synchronised	
	Tapping feet and fingers – same side synchronised	
Balance	Walking forward on a line	
	Standing on one leg on a balance beam with eyes open	
Upper Limb Coordination	Dropping and catching a ball - both hands	
	Dribbling a ball - alternating hands	
Strength	Knee push-ups	
	Sit-ups	
Speed and Agility	One-legged stationary hop	

Appendix 6: BOT-2 Short Form Results

Paired samples t-test			
Test Item	Pre: Mean (Standard Deviation)	Post: Mean (Standard Deviation)	Significance (p)
Drawing a line through paths crooked	5.00 (± 1.835)	5.00 (± 1.919)	1.000
Folding paper	2.80 (± 1.908)	3.10 (± 1.683)	0.554
Copying a square	3.90 (± 1.165)	4.20 (± 0.616)	0.209
Copying a star	2.05 (± 1.605)	2.70 (± 1.720)	0.012
Transfer of pennies	1.75 (± 0.851)	3.45 (± 1.050)	0.000
Jumping in place – same side synchronised	2.95 (± 0.224)	2.90 (± 0.447)	0.330
Tapping feet and fingers – same side synchronised	3.40 (± 1.273)	3.70 (± 0.657)	0.055
Walking forward on a line	3.85 (± 0.489)	3.95 (± 0.224)	0.163
Standing on one leg on a balance beam with eyes open	3.30 (± 1.081)	3.30 (± 0.979)	1.000
Dropping and catching a ball - both hands	4.00 (± 1.747)	4.20 (± 1.473)	0.297
Dribbling a ball – alternating hands	2.90 (± 1.683)	3.50 (± 1.732)	0.019
Sit-ups	3.25 (± 1.372)	3.65 (± 1.089)	0.017
Knee push-ups	3.65 (± 1.663)	3.95 (± 1.538)	0.316
One-legged stationary hop	7.45 (± 1.761)	8.15 (± 1.22)	0.003

Independent samples t-test			
Test Item	Pre: Mean (Standard Deviation)	Post: Mean (Standard Deviation)	Significance (p)
Drawing a line through paths crooked	Control: 4.50 (± 1.792)	Control: 4.35 (± 1.694)	0.263
	Intervention: 5.00 (± 1.835)	Intervention: 5.00 (± 1.919)	
Folding paper	Control: 2.70 (± 2.203)	Control: 2.85 (± 2.231)	0.691
	Intervention: 2.80 (± 1.908)	Intervention: 3.10 (± 1.683)	
Copying a square	Control: 3.50 (± 1.395)	Control: 3.70 (± 1.418)	0.156
	Intervention: 3.90 (± 1.165)	Intervention: 4.20 (± 0.616)	
Copying a star	Control: 2.40 (± 1.569)	Control: 2.40 (± 1.501)	0.560
	Intervention: 2.05 (± 1.605)	Intervention: 2.70 (± 1.720)	
Transfer of pennies	Control: 2.00 (± 0.858)	Control: 2.25 (± 0.967)	0.001
	Intervention: 1.75 (± 0.851)	Intervention: 3.45 (± 1.050)	
Jumping in place – same side synchronised	Control: 2.65 (± 0.933)	Control: 2.65 (± 0.933)	0.287
	Intervention: 2.95 (± 0.224)	Intervention: 2.90 (± 0.447)	

Tapping feet and fingers – same side synchronised	Control: 3.75 (± 0.786)	Control: 3.75 (± 0.786)	0.828
	Intervention: 3.40 (± 1.273)	Intervention: 3.70 (± 0.657)	
Walking forward on a line	Control: 4.00 (± 0.000)	Control: 3.95 (± 0.224)	1.000
	Intervention: 3.85 (± 0.489)	Intervention: 3.95 (± 0.224)	
Standing on one leg on a balance beam with eyes open	Control: 3.55 (± 0.999)	Control: 3.50 (± 1.000)	0.527
	Intervention: 3.30 (± 1.081)	Intervention: 3.30 (± 0.979)	
Dropping and catching a ball - both hands	Control: 3.80 (± 1.399)	Control: 3.95 (± 1.432)	0.589
	Intervention: 4.00 (± 1.747)	Intervention: 4.20 (± 1.473)	
Dribbling a ball – alternating hands	Control: 2.60 (± 1.392)	Control: 2.50 (± 1.357)	0.049
	Intervention: 2.90 (± 1.683)	Intervention: 3.50 (± 1.732)	
Sit-ups	Control: 3.55 (± 1.276)	Control: 3.65 (± 1.496)	1.000
	Intervention: 3.25 (± 1.372)	Intervention: 3.65 (± 1.089)	

Knee push-ups	Control: 3.55 (± 1.538)	Control: 3.80 (± 1.673)	0.769
	Intervention: 3.65 (± 1.663)	Intervention: 3.95 (± 1.538)	
One-legged stationary hop	Control: 7.55 (± 1.276)	Control: 7.45 (± 1.395)	0.100
	Intervention: 7.45 (± 1.761)	Intervention: 8.15 (± 1.226)	

Analysis of covariance	
Test Item	Significance (p)
Drawing a line through paths crooked	0.482
Folding paper	0.709
Copying a square	0.302
Copying a star	0.039
Transfer of pennies	0.000
Jumping in place – same side synchronised	0.198
Tapping feet and fingers – same side synchronised	0.049
Walking forward on a line	0.292
Standing on one leg on a balance beam with eyes open	0.000
Dropping and catching a ball - both hands	0.706

Dribbling a ball – alternating hands	0.006
Sit-ups	0.247
Knee push-ups	0.826
One – legged stationary hop	0.001

Appendix 7: Manuscript

The Effect of a Sport Stacking Intervention Programme On Fine and Gross Motor Skills In Preschool Children

Bhavik Daya

University of KwaZulu-Natal, Durban, South Africa

Abstract

The development of motor skills in children plays an important role in the level of physical activity children engage in. If a child cannot efficiently run, kick, jump, catch, etc., then the opportunities to participate in sport and other physical activities will become limited because they will not have the necessary skills to do so. Sport stacking is believed to improve motor proficiency. The aim of this study is to investigate the effects of a five-week sport stacking intervention programme on fine and gross motor skills in preschool children. The study was a quasi-experimental non-equivalent controls design with a pre- and post-intervention assessment. Forty participants between the ages of four and six years participated in the study. The control and intervention groups both comprised of 20 children. At pre-test and post-test, fine and gross motor skills were assessed using the Bruininks-Oseretsky Test of Motor Proficiency, second edition. After the sport stacking intervention programme, the intervention group significantly improved in the areas of copying a star, transfer of pennies, dribbling a ball – alternating hands, sit-ups, one legged stationary hop and tapping feet and fingers – same side synchronised. The control group showed no significant improvements being made in both fine and gross motor skills. The results show that a sport stacking intervention programme is a suitable method to improve fine and gross motor skills in preschool children.

Keywords

Sport stacking, fine motor skills, gross motor skills

Introduction

Sport stacking, also known as cup stacking or speed stacking originated during the 1980s in Southern California in the United States of America (USA) (Speedstacks, 2013.)Sport stacking involves participants using both hands to stack cups in a certain sequence to make a pyramid and then return the cups back into stacks (Speedstacks, 2016.) Sport stacking initially involved the use of paper cups, but due to its fragile nature, it was changed to plastic cups (Udermann & Murray, 2006). Through educational programmes in the USA, sport stacking gained international recognition in several countries such as Australia, Canada, Germany and the United Kingdom (Udermann & Murray, 2006).

Sport stacking is said to improve hand eye coordination, reaction time and motor proficiency. According to Udermann et al. (2004), sport stacking improved hand eye coordination and reaction time in second grade students and this is important because hand eye coordination and reaction time play an important role in many human movements. The children were divided into a control group and intervention group. The intervention group were required to perform sport stacking for 20-30 minutes per day, four times a week for five weeks. The control group were required to continue with their normal physical education classes. The results of the study showed that sport stacking significantly improved the children's quickness and reaction time.

Conn (2004) assessed the effect of sport stacking on reaction time, movement time and ambidexterity in 82 fourth grade students. The students performed a five-week programme that combined sport stacking with scooter and volleyball skills. The students stacked for a total of four hours and 40 minutes. The results of the study showed that there was a significant difference in movement time but no differences in reaction time.

The effect of sport stacking on auditory and visual attention in 32 Grade three children was assessed. The participants were randomly assigned to either the sport stacking or arts/crafts group with each group consisting of 16 participants. The participants performed sport stacking or arts/crafts for three weeks, which was followed by a three-week wash-out period, after which a cross-over was implemented and the intervention programme was repeated. Results showed that sport stacking could lead to improvements in high demand function and fine motor regulation (Mortimer et al., 2011).

Movement can be classified as fine and gross motor skills. Fine motor skills refer to the coordination of the small muscle groups in the hands to operate tools such as pencils, scissors and crayons accurately (Smith, 2003). Gross motor skills refer to the use of the whole body to perform large movements such as running, hopping, jumping, catching, etc. (de Witt, 2009). Gross motor skills are required to move, stabilise and control the body as well as objects when exploring the environment and well-developed gross motor skills will help an individual to function more efficiently later in life.

Fine motor skills gradually develop through each developmental stage of a child's life and will keep on developing with age, practice, as well as playing sports and playing musical instruments (Meggitt, 2006). From the age of four, the child will start to fold pieces of paper, thread approximately twelve beads, begins to use a scissors, and enjoys playing with big blocks. Between the ages of five and six, the child's fine muscle coordination becomes more refined and they can copy shapes such as circles and squares, draw pictures that are more recognisable and will use their hands more than their arms when catching objects. Placing pegs into a peg board, colouring and tracing of shapes and letters as well as using modelling clay to form letters are activities that can be used to improve fine motor skills (Case-Smith et al., 1998; Lust & Donica, 2011).

A study by Katz (2005) was conducted to determine school readiness in 24 children across three Grade R classes in Cape Town, South Africa. The children were assessed on classroom performance (literacy, numeracy and conceptual formation), fine motor skills, visual perception and the ability to combine fine motor skills and visual perception. The results of the study indicated that most of the children had difficulty in most of the areas assessed. Similar findings were also found in a study conducted by Pretorius and Naude (2002) who assessed 30 preschool children and found significant deficits in fine motor skills and various cognitive skills.

Gross motor skills also develop through each developmental stage of a child's life but the development of the gross motor movements precedes that of the fine motor skills (de

Witt, 2009). Between the ages of four and five, the child begins to run fast, run up and down stairs, can walk in a straight line, starts to climb trees and can ride a tricycle. At age five, the child can catch a ball, kick a ball while running, climb fences and begins to dress and undress themselves. At age six, the child can jump over a rope using both feet and will start to run and skip on the jungle gym. Gross motor skills can be improved by performing various exercises such as balancing on a balance beam, push-ups, catching a beanbag, balancing on a balance board, hand stands, crawling on hands and knees as well as side to side jumping and barefoot forward balancing (Donath et al., 2014; Vidoni et al., 2014).

du Toit & Pienaar (2002), examined the current level of gross motor development in South African preschool children in Potchefstroom. The study involved 462 children between the ages of three and six and they were tested on eight motor tasks (hopping, one leg balance, jumping jacks, standing long jump, skipping, throwing, balance walk and catching) The results of the study showed that the tests for throwing, balance walk and catching between the three to five year olds were lower than the normative data and that the results for the six year olds found that they scored below the normative data for all the tests except for the standing long jump.

A study to examine the effects of a creative movement programme on gross motor skills in preschool children was conducted by Wang (2004). Participants were 60 preschool children between the ages of three and five. The experimental group performed the creative movement programme twice a week for 30 minutes per session. The control group performed only unstructured free play. The results of the study found that the experimental group scored significantly higher ($p < .05$) than the control group in gross motor skills.

Physical inactivity is defined as doing none or very limited physical activity at work, home and school as well as transport to and from places (Micklesfield et al., 2014). Sedentary behaviour is defined as behaviours such as watching television and playing on the computer that have minimal physical movements and little energy expenditure - typically less than or equal to 1.5 Metabolic equivalent tasks (METs) (Tremblay et al., 2010). A criticism of sport stacking is that individuals engage in little physical activity whilst performing sport stacking, however a study by Murray et al. (2007) states that sport stacking has an energy expenditure of 3.1 METs. Thirty-seven subjects participated in this study and expired respiratory gases as well as the heart rate of participants were monitored for ten minutes. The results of the study showed that sport stacking has an energy expenditure of 3.1 METs, which is similar to performing other physical activities that include bowling, archery and volleyball. Therefore, sport stacking can be classified as a moderate to vigorous physical activity.

Physical inactivity is on the rise among both children and adolescents, with numerous studies in high-income countries revealing an increase in both overweight and obesity amongst the population (Micklesfied et al., 2014). Preschool children are highly physically active and studies have showed that children between the ages of three and five are more physically active than older children (Pate et al., 2008).

The Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) and its review, the Bruininks-Oseretsky Test of Motor Proficiency, second edition (BOT-2) are tools used to assess fine and gross motor skills in individuals (Carmosino et al., 2014).

The short form consists of 14 items from the eight subtests (Fransen et al., 2014).

Table 1. Items assessed in the BOT-2 short form

Subtest	**Item**
Fine motor precision	Drawing a line through crooked paths
	Folding paper
Fine motor integration	Copying a square
	Copying a star
Manual dexterity	Transfer of pennies
Bilateral coordination	Jumping in place – same side synchronised
	Tapping feet and fingers – same side synchronised

Balance	Walking forward on a line
	Standing on one leg on a balance beam with eyes open
Running, speed and agility	Jumping on one leg
Upper limb coordination	Dropping and catching a ball using both hands
	Dribbling a ball with alternating hands
Strength	Knee push-ups
	Sit-ups

The score an individual receives can be the number of points, correct activities performed or time in seconds for each item (Matson, 2015) and a high correlation has been found between the two BOT-2 forms (Cools et al., 2009).

The research on the benefits of sports stacking on fine and gross motor skills among preschool children is limited. Thus, the aim of this study was to examine the effects of a sports stacking intervention programme on the fine and gross motor skills in preschool children.

Hypothesis: A sport stacking intervention programme will improve fine and gross motor skills in preschool children.

Null hypothesis: A sport stacking intervention programme will not improve fine and gross motor skills in preschool children.

Method

The study was a quasi-experimental non-equivalent controls design with a pre- and post-intervention assessment. The intervention programme was conducted over five weeks. Pre- and post-test measures of participants height, weight and body mass index (BMI) were determined along with the fine and gross motor skills assessment using the Bruininks-Oseretsky Test of Motor Proficiency, second edition (BOT-2 short form).

Participants

In total, there were 26 males and 14 females that participated in this study. The average age for participants in the intervention group was 5.3 (*SD* = 1.011) years old and the average age for participants in the control group was 5.1 (*SD* = 0.921) years old. The average BMI for the entire population (pre-test) was 16.36 kg/m^2 (*SD* = 1.54) and 16.41 kg/m^2 (*SD* = 1.55) (post-test).

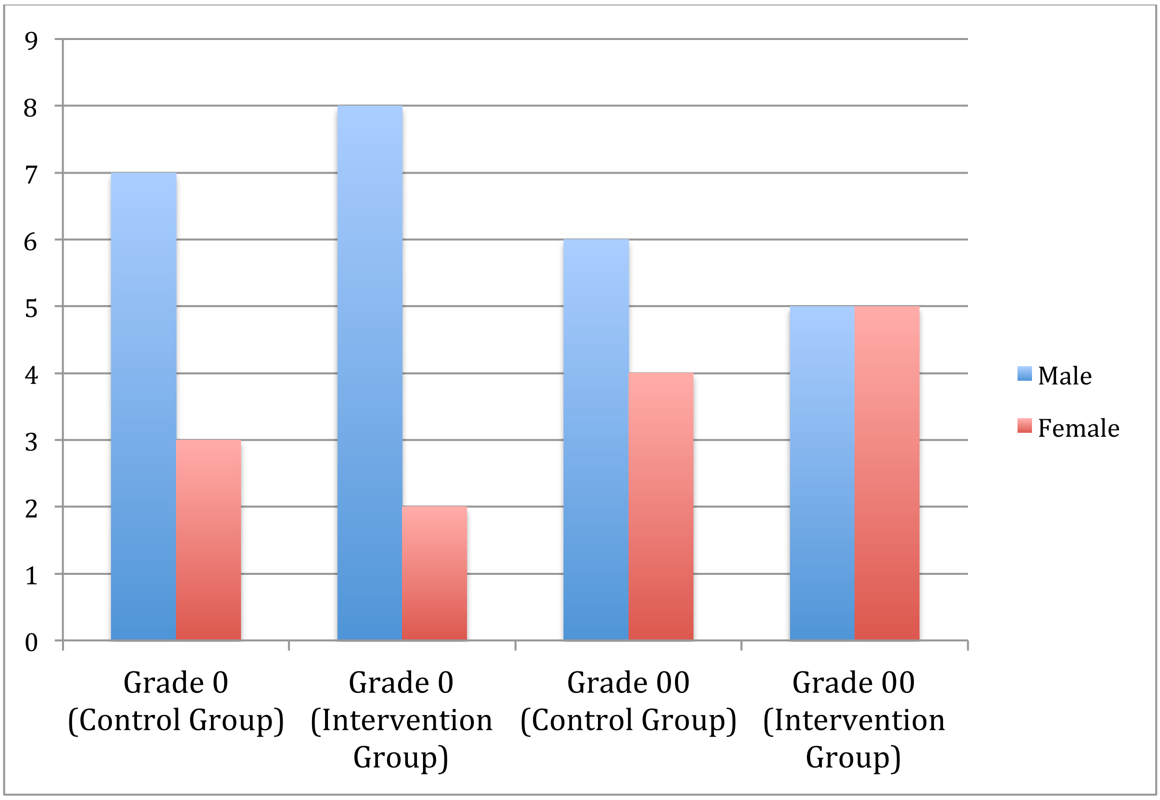

Figure 1. Sample distribution

The intervention group comprised of 20 participants and participated in a sport stacking intervention programme that included fine and gross motor activities. The control group comprised of 20 participants and continued with their daily school routine.

Both groups comprised of participants that were between the ages of four and six, had no prior exposure to sport stacking and were physically abled to participate in moderate to vigorous physical activity.

Prior to the commencement of the study, gatekeeper's permission was obtained from the principal's at Ocean View Montessori School. The parents/guardians of participants that adhered to the inclusion criteria received an information sheet and were required to complete the parental consent form. Ethical clearance from the Biomedical Research Ethics Committee (BFC389/16) was obtained and the study commenced.

Measures

Anthropometric assessment (height, weight and BMI) were measured pre-test and post-test. Height was measured using a stadiometer (a steel ruler or measuring tape securely stuck to a wall). Weight was measured using a scale. Body mass index was calculated by dividing body weight in kilograms by height in meters squared to determine the individuals weight relative to their height (Whaley et al., 2006).

Fine and gross motor skill assessment was measured using the BOT-2 short form.

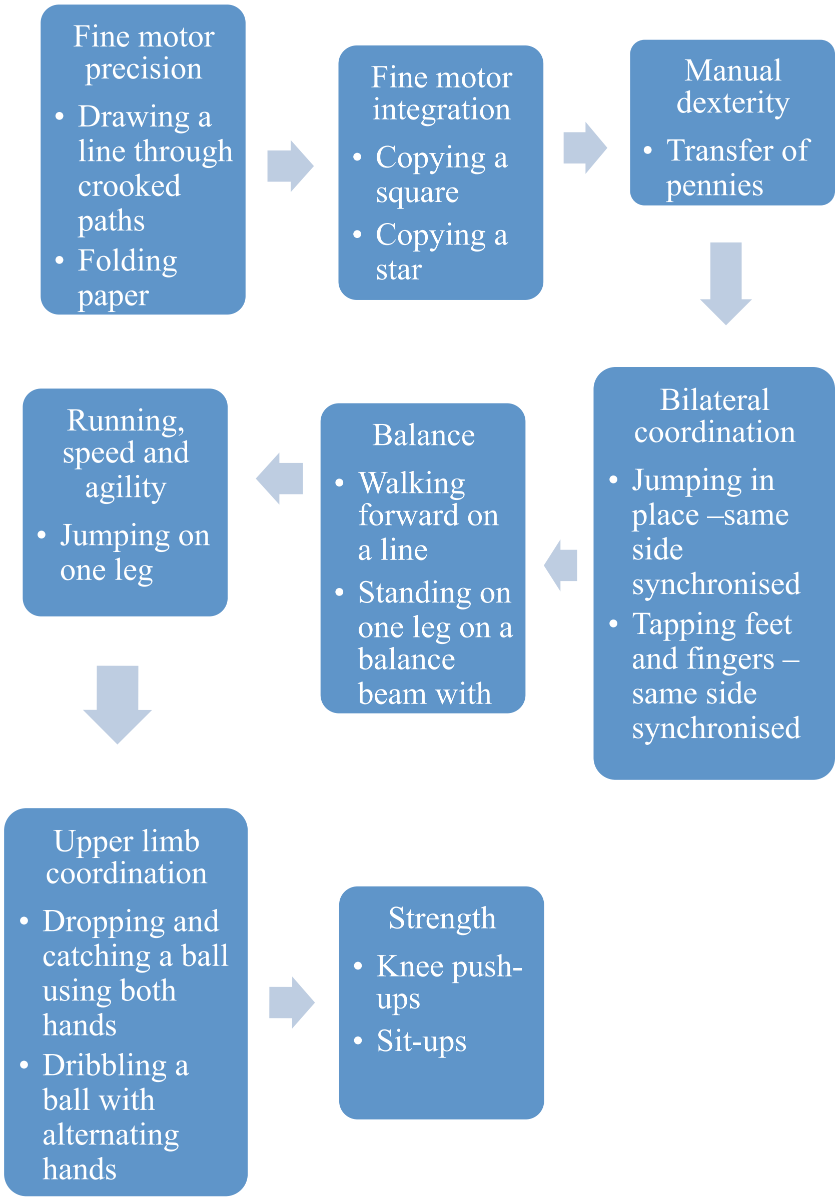

Figure 2. Testing order for the BOT-2 short form.

Sport Stacking Intervention Programme

The sport stacking intervention programme consisted of two sessions a week for five weeks. The duration for each session was between 30-45 minutes. Fine motor skill and gross motor skill activities were performed on separate days. Gross motor activity sessions consisted of a warm-up and cool-down. The researcher, a qualified exercise scientist and sports coach administered all pre- and post-testing as well as conducted the intervention programme.

Table 2. Sport stacking intervention programme

WEEK	DAY 1 ACTIVITIES	DAY 2 ACTIVITIES
1	• Sport stacking • Opening and closing locks with keys • Placing beads onto a soap pad using tweezers	• Sport stacking • Balancing on one leg with eye's open and closed • Hop scotch
2	• Sport stacking • Threading of both large and small beads • Button frame	• Sport stacking • Walking in a straight line with a bean bag on the heads of participants • Throwing a ball/beanbag through a hoola hoop
3	• Sport stacking • Transferring water into ice cube trays using a pipette. • Pink tower	• Sport stacking • Jumping on a springboard and catching a bean bag • Using a hoola hoop
4	• Sport stacking • Nuts and bolts • Tracing- Insets for design	• Sport stacking • Throwing a ball at objects • Walking on a balance beam
5	• Sport stacking • Knobbed/knobless cylinders • Picking up and placing of items into a correct container using a peg	• Sport stacking • Walking on stilt buckets • Bouncing a ball in a straight line

Analysis

The data collected in this study was subjected to various statistical procedures. All the data was analysed by a computerised statistical procedure (SPSS Version 19) and descriptive (means and standard deviations) and inferential (paired t-tests and independent t-tests) statistics, analysis of covariance (ANCOVA) and effect sizes were used to test significant differences pre- and post-intervention with $p \leq 0.05$.

Results

For each of the skills assessed, various statistical analyses were conducted.

Firstly, the paired samples t-test (Table 3) was applied to test for significant differences pre- and post-intervention for the control and intervention groups.

Table 3. Results for paired samples t-test.

Test Item	Pre: Mean (SD)	Post: Mean (SD)	Significance (p)
Copying a star	2.05 (± 1.605)	2.70 (± 1.720)	0.012
Transfer of pennies	1.75 (± 0.851)	3.45 (± 1.050)	0.000
Dribbling a ball – alternating hands	2.90 (± 1.683)	3.50 (± 1.732)	0.019
Sit Ups	3.25 (± 1.372)	3.65 (± 1.089)	0.017
One-legged stationary hop	7.45 (± 1.761)	8.15 (± 1.22)	0.003

The paired samples t-test for the control group showed no significant differences for each of the items assessed. However, for the intervention group, significant differences for copying a star ($p = 0.012$); transfer of pennies ($p = 0.000$); dribbling a ball – alternating hands (p = 0.019); sit ups (p = 0.017); and one-legged stationary hop (p = 0.003) was evident.

Independent samples t-test (Table 4) were conducted to test for significant differences in the pre-scores and post-scores across the control and intervention groups.

Table 4. Results for independent samples t-test.

Test Item	**Pre: Mean (SD)**	**Post: Mean (SD)**	**Significance (p)**
Transfer of pennies	Control: 2.00 (± 0.858)	Control: 2.25 (± 0.967)	0.001
	Intervention: 1.75 (± 0.851)	Intervention: 3.45 (± 1.050)	
Dribbling a ball – alternating hands	Control: 2.60 (± 1.392)	Control: 2.50 (± 1.357)	0.049
	Intervention: 2.90 (± 1.683)	Intervention: 3.50 (± 1.732)	

There were only two skills that showed significantly different scores for the two groups, i.e. post-transfer of pennies and post-dribbling a ball – alternating hands.

There was a significant difference in the post-score for the transfer of pennies across the two groups (p = 0.001). The score for the control group (M = 2.25, SD = ± 0.967) was significantly lower than the experimental group (M = 3.45, SD = ± 1.050).

There was also a significant difference in the post-score for dribbling a ball – alternating hands across the two groups (p = 0.049). The score for the control group (M = 2.50, SD = ± 1.357) was significantly lower than the experimental group (M = 3.50, SD = ±1.742).

Analysis of covariance (Table 5) were applied to test whether the intervention had a significant effect on the post-scores after correcting for the pre- scores.

Table 5. Results for analysis of covariance

Test Item	Significance (p)
Copying a star	0.039
Transfer of pennies	0.000
Tapping feet and fingers – same side synchronised	0.049
Dribbling a ball – alternating hands	0.006
One – legged stationary hop	0.001

Analysis of covariance showed no significant differences for the control group. Copying a star (p = 0.039); transfer of pennies (p = 0.000); tapping feet and fingers – same side synchronised (p = 0.049); dribbling a ball – alternating hands (p = 0.006) and the one – legged stationary hop (p = 0.001), showed significant improvements post- intervention.

The effect sizes (Table 6) were calculated for each skill for both groups separately and shows the effect size and the classification of the effect size (small, medium or large) for both groups.

Table 6. Effect Sizes for control and intervention group

Item Assessed For Control Group	**Effect Size**	**Classification Of Effect Size**
Transfer of pennies	0.3	Small
Knee push-ups	0.2	Small
Item Assessed For Intervention Group	**Effect Size**	**Classification Of Effect Size**
Folding paper	0.2	Small
Copying a square	0.3	Small
Copying a star	0.4	Small
Transfer of pennies	1.8	Large
Tapping feet and fingers – same side synchronised	0.3	Small
Walking forward on a line	0.3	Small
Dribbling a ball - alternating hands	0.4	Small

Knee push-ups	0.2	Small
Sit ups	0.3	Small
One-legged stationary hop	0.5	Medium

According to Vacha-Haase & Thompson (2004), an effect size is classified using Cohens's *d.* An effect size with a Cohen's *d* value of 0.2 is regarded as a small effect. A medium effect size is classified with a Cohen's *d* value of 0.5 and a large effect size is classified with a Cohen's *d* value of 0.8.

The control group identified two items (transfer of pennies and knee push-ups) that resulted in a small effect.

The intervention group identified eight items (folding paper, copying a square, copying a star, tapping feet and fingers – same side synchronised, walking forward on a line, dribbling a ball - alternating hands, knee push-ups and sit-ups) resulting in a small effect. The one-legged stationary hop resulted in a medium effect and the transfer of pennies resulted in a large effect.

Discussion

The aim of this study was to examine the effects of a sports stacking intervention programme on fine and gross motor skills in preschool children. The objectives of the study were to assess both fine and gross motor skills pre- and post-intervention.

Fine and gross motor skills play an important role throughout a person's lifetime. Poor motor skills can result in limited opportunities for a child to participate in sport and other physical activities, as they will not have the necessary motor skills to perform these activities (Stodden et al., 2008).

The results from this study shows that the sport stacking intervention programme resulted in improvements in selected components of both fine and gross motor skills. Various statistical analyses showed significant differences in both fine and gross motor skills particularly in the areas of fine motor integration for copying a star (paired samples t-test: $p = .012$ and ANCOVA: $p = 0.039$), manual dexterity (paired samples t-test: $p = .000$, independent samples t-test: $p = .001$ and ANCOVA: $p = .000$), bilateral coordination for tapping feet and fingers – same side synchronised (ANCOVA: $p = .049$), upper limb coordination for dribbling a ball – alternating hands (paired samples t-test: $p = .019$, independent samples t-test: $p = .049$ and ANCOVA: $p = .006$), strength for sit-ups (paired samples t-test: $p = .017$) and running, speed and agility (paired samples t-test: $p = .003$ and ANCOVA: $p = .001$).

The results of this study indicate that the bilateral movement between both the left and right hands appears to have resulted in improvements in manual dexterity and certain components of both bilateral coordination and upper limb coordination of the intervention group post-intervention.

The results for manual dexterity showed that the intervention group improved significantly (paired samples t-test: $p = .000$, independent samples t-test: $p = .001$ and ANCOVA: $p = .000$) when all tests were applied to test for significant differences pre- and post-intervention. Therefore, sport stacking could have contributed to the significant improvement of manual dexterity as sport stacking involves the use of both hands. On the contrary, results from Tortella et al. (2016) who examined the effects of structured and unstructured activities on motor competence in five-year-old children, found no significant improvements for manual dexterity post-intervention for the intervention group. Activities performed included rope ladder, climbing rope, hanging bar, gymnastic rings, climbing net, monkey bars, balance beam, balance logs, balance elastic beam and balance platforms. However, it is important to note that their programme focused on gross motor skills and no opportunities were given to enhance the development of fine motor skills, which could have played a major role in improving manual dexterity. Li et al. (2011) also found improvements, although not significant in manual dexterity for Grade two children that participated in a 12-week sport stacking intervention programme.

The pre-test time of 67.43 seconds improved to 61.07 seconds (post-test). Manual dexterity was measured using a grooved pegboard where as this study used the transfer of pennies to measure manual dexterity. The mean scores for the intervention group in the current study showed that manual dexterity improved from 1.75 (pre-test) to 3.45 (post-test).

In the current study, the items assessed for bilateral coordination were jumping in place – same side synchronised and tapping feet and fingers – same side synchronised. Only tapping feet and fingers – same side synchronised (p = .049) showed significant improvement when ANCOVA was used to test for significance. This difference could be as a result of both hands being used when performing sport stacking. Similarly, Rhea et al. (2006) found that the intervention group, after performing sport stacking for five weeks, had a positive effect on bilateral coordination in sixth grade physical education students.

The tests performed for upper limb coordination were dropping and catching a ball using both hands and dribbling a ball with alternating hands. Dropping and catching a ball using both hands showed no significant differences however, significant improvements were made in dribbling a ball with alternating hands when all tests were applied to test for significant differences. Sport stacking could have had a direct effect on dribbling a ball with both hands as both hands are required when performing sport stacking and when dribbling a ball. Dribbling a ball also incorporates hand eye coordination and Li et al. (2011) measured hand eye coordination using a grooved pegboard, found improvement in hand eye coordination in the intervention group as the time for the photoelectric rotary pursuit tracking test improved from 9.22 seconds (pre-test) to 11.31 seconds (post-test).

The fine and gross motor skill activities that were performed in conjunction with sport stacking appear to have made significant differences in certain areas of fine motor integration, strength and speed and agility. The results from the study for fine motor integration showed that the intervention group improved in both copying a star and copying a square with only copying a star showing a significant improvement. The average score for copying a square increased from 3.90 to 4.20 (p = .209) whereas the average score for copying a star significantly increased from 2.05 to 2.70 ($p = .012$). The pre-test results for copying a square were much higher than for copying a star which could indicate that copying a star was more difficult than copying a square. Hence, the inclusion of a movement skill programme into the preschool curriculum can improve children's fine motor integration. This is supported by Vidoni et al. (2014), as their study showed that post-test scores of 18 children that participated in the intervention programme, all 18 participants improved in copying a star, where as only 13 participants showed an improvement in copying a square. According to Lane (2005), a child should begin to draw a square at the age of four and it takes approximately two years of development for a child to progress from drawing a square to a vertical diamond. Given that the average age of the intervention group was 5.3 ($SD = 1.011$) years, the significant difference made in copying a star is justified.

The results for fine motor integration by Lust and Donica (2011) showed a significant improvement in fine motor integration ($p = .021$) in children between the ages of four and five. Their study's intervention programme focused on fine motor precision and fine motor integration skills which included activities such as body awareness skills, directional concepts, letter-play activities as well as colouring and tracing of capital letters and shapes, compared to the multiple fine motor skills focused on in this study.

Knee push-ups and sit-ups were tested for strength. Only sit-ups showed a significant difference between pre- and post-test scores after the intervention programme when the paired samples t-test was applied to test for significance ($p = 0.017$). However, it is important to note that the intervention programme did not focus primarily on upper body strength and endurance. Significant differences made for sit-ups could be a direct result of involvement in extramural activities such as monkeynasticks, swimming, little kickers (soccer) and ballet. Vidoni et al. (2014) showed improvement being made in both sit-ups (18 out of 18 participants) and knee push-ups (16 out of 18 participants) in their 11-week structured physical activity intervention programme. Activities included push-ups, pencil rolls, crawling on hands and knees on the floor, hand-stands on mat against the wall, back lifts and somersaults on a mat could have resulted in strength improvements.

Results for running, speed and agility in the one-legged stationary hop showed significant differences when both the paired samples t test was applied to test for significance for the intervention group ($p = .003$) and when ANCOVA was used to assess for significance ($p = .001$). Activities in the intervention programme that included hopscotch and jumping on a springboard could have resulted in the significant improvements being made in running, speed and agility.

The two subtests for fine motor precision performed in this study were drawing a line through crooked paths and folding paper. The results of the study showed that the intervention programme had no significant effect on both drawing a line through crooked paths and folding paper. These results do not coincide with the results obtained from Donica et al. (2011) in which significant differences were found in the intervention group (*M* = 8.47, *SD* = 4.31 with $p = .045$). The reasons for the significant improvements made in fine motor precision could be as a result of the study focusing primarily on fine motor precision and fine motor integration skills such as letter – play activities, colouring, tracing of capital letters and tracing of shapes whereas the current study's intervention programme focused on multiple fine motor activities and not just fine motor precision and fine motor integration skills. The short duration of this study compared to the long duration of their intervention programme (from October to March and consisted of three sessions a week), could have played a role in the improvements made in fine motor precision.

Walking forward on a line and standing on one leg on a balance beam with eyes open were the tests applied for balance. Both walking forward on a line and standing on one leg on a balance beam with eyes open showed no significant differences pre- and post-intervention. Balancing on one leg with eye's open and closed, hop scotch, walking in a straight line with a bean bag on head, walking on a balance beam and walking on stilt buckets were activities performed in the intervention programme for the intervention group which focussed on balance. The BOT-2 short form maximum score for walking forward on a line and standing on one leg on a balance beam with eyes open is four. The average score for the intervention group was 3.85 (pre-test) and 3.95 (post-test) for walking forward on a line and 3.30 (pre-test) and 3.30 (post-test) for standing on one leg on a balance beam with eyes open. The pre-test scores for both items assessed for balance show that the intervention group scores were high to begin with; hence no significant improvements being made as the pre-test scores left little room for improvement. The average score for both the pre- and post-test scores for the intervention group for standing on one leg on a balance beam with eyes open was 3.3 out of 4 which indicates that participants were able to balance for approximately 6.0-9.9 seconds. Additionally, a child at the age of five should be able to balance on one leg for more than eight seconds and be able to walk heel to toe backwards (Glascoe & Robertshaw., 2010).

The results show that a sport stacking intervention programme does improve fine and gross motor skills in preschool children, therefore the hypothesis of the study is accepted. Overall, the control group showed no significant improvements in both fine and gross motor skills.

This study had several limitations. Firstly, the number of participants in this study was small. Secondly, the number of males and females were unequal which may have had an effect on the results. Thirdly, gender differences were not considered. Lastly, the study was conducted over five weeks and the benefits may only be short-term.

Declaration of Conflicting Interests

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