Comparing the Effect of Task-Oriented Intervention Program vs. Strength Training Program in Improving Motor Proficiency in Children Aged 8-12 Years with Developmental Coordination Disorder (DCD): A Randomized Controlled Pilot Study

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Submitted in part-fulfilment of the requirements for the degree of Master of Sport and Exercise Science

Centre for Sport Science and Human Performance

Waikato Institute of Technology

December 2017

Keywords

Developmental Coordination Disorder (DCD)
Enjoyment level
Movement Assessment Battery for Children (MABC-2)
Motor Proficiency
Motor Skills
Strength Training Program
Task-Oriented Program

Abstract

Background: Despite the fairly high prevalence of developmental coordination disorder (DCD) among children (5-6% of school population), existing research and therapeutic practice lack rigorously conducted, randomised controlled studies that could be instrumental in finding the most effective intervention programs as judged by improvements of various facets of patients' motor proficiency, their physiological status, and adherence rates.

Purpose: This study sought to compare the outcomes of task-oriented and strength training exercise intervention programs in terms of improving motor proficiency as well as the levels of enjoyment and compliancy to treatment among children with DCD.

Design: Randomized controlled pilot trial.

Methods: Eighteen children aged 8-12 years diagnosed with DCD were randomly assigned to the task-oriented exercise program (n=9) or strength training program (n=9). Children were assessed using the Developmental Coordination Questionnaire and the Movement Assessment Battery for Children, as well as a battery of self-reported measures of enjoyment and the level of parental encouragement needed. Intervention consisted of 8-week exercise physiologist-led individual or group exercise sessions held once a week plus a series of home exercise program.

Analysis: A series of one-way ANOVAs and paired t-tests were used to investigate the within-group and between-group effects of the two programs. Multiple linear regressions were run to test whether and which contextual and child-related characteristics affected the treatment success.

Results: Both programs have led to statistically significant improvements in terms of children's motor proficiency as measured by total score ($p<.001$ for both groups), manual dexterity ($p=.004$ and $p=.001$ in the task-oriented and strength-training groups, respectively), ball skills ($p<.001$ in the in the task-oriented group), and balance ($p<.001$ and $p<.01$). The group allocation did not influence the post-treatment results. No statistically significant differences were found between the two programs in terms of enjoyment and encouragement levels.

Conclusion: The task-oriented and strength training intervention programs present an effective, patient-friendly strategy for improving motor performance among children with DCD that produce comparable outcomes and can be recommended for further use in therapeutic practice.

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Statement of Original Authorship

The work contained in this thesis has not been previously submitted to meet requirements for an award at this or any other higher education institution. To the best of my knowledge and belief, the thesis contains no material previously published or written by another person except where due reference is made.

Signature: Alena Adaikina_____

Date: 15.12.2017._____

Acknowledgements

I would like to express my sincerest gratitude and appreciation to the people who have assisted me and contributed to the accomplishment of this degree.

I am particularly grateful to my supervisor Dr. Glynis Longhurst for her guidance and continuous support through my two years at Wintec, for her advice and sharing her expertise in this particular field, her valuable and constructive suggestions during the planning and implementation of this work.

My special thanks are extended to the staff of the School of Sport and Exercise Science of Wintec led by Greg Smith for their continued support and encouragement.

Thanks to Craig Harington and Mary Silcock for the interest in this research, their help in providing invaluable resources in running this project.

My special words of gratitude go to the 20 children and their families who participated in this study on top of all of their other activities. The time dedication of these families to this research was incredible. Without you, this study would not have been possible. I would also like to thank the teachers of schools for their help in the recruitment process and for providing the school facilities to run exercise sessions.

I also want to acknowledge the help provided by Sagun Mahajan.

Finally, I wish to express my sincere thanks to my husband Dmitrii and our children, Ivan and Katsiaryna, my dear mother Nina, sister Volha and her family for all of their patience and confidence in me, and for their incredible support in all the challenges I had to cope with on the way to making this project happen. Hopefully, I am making you proud. My last, but not least, “thank you” goes to my late dad, Petr. I know you are with me in spirit.

Chapter 1: Introduction

1.1. BACKGROUND

Developmental Coordination Disorder (DCD) has been recognized as one of the most common developmental dysfunction during childhood (Blank, Ouwien Smits-Engelman, Polatajko, & Wilson, 2012) with worldwide distribution from 5-6% (American Psychiatric Association, 2013; Gaines, Missiuna, Egan, and McLean, 2008) to 5-10% (Wilmut, Brown, & Wann, 2007).

DCD is characterized by difficulties in performing everyday motor skills that are not attributed to another physical, sensory or intellectual impairment (Wilson & Crawford, 2007).

Compared with the typical development children, children with DCD are reported to demonstrate poorer performance of ADL, delays in learning ADL and less frequent participation in physical activities (Missiuna, Moll, King, & Law, 2007; Summers, Larkin, Dewey, 2008; Van der Linde, Van Netten, Otten, Postema, Geuze, and Schoemaker, 2015; Zwicker, Harris, & Klassen, 2012), the symptoms treated as diagnostic criteria for DCD (American Psychiatric Association, 2013).

1.2. STATEMENT OF THE PROBLEM

The review of the existing research has revealed two main points. First of all, developmental coordination disorder is a broadly defined problem that affects a lot of children and has negative impact not only on their motor skills, balance, strength, but also daily activity, social life, psychological health and learning process as well (Fong, Velma, Lee, Chan, Chak, and Pang, 2011; Jarus, Lourie-Gelberg, Engel-Yeger, & Bart, 2001; Poulson, Ziviani, Cuskelly, & Smith, 2007; Poulson, Ziviani, Johnson, Cuskelly, 2008; Van der Linde et al., 2015).

Second, existing research and therapeutic practice suffer from a lack of rigorously conducted, randomised controlled studies that could be instrumental in finding the best intervention program as judged by not only improvements of patients' motor proficiency, but their physiological status as well (Summers et al., 2008; Zwicker et al., 2012).

Moreover, there is a clear need in finding an optimal program for children in different age groups as well as exploring ways to adjust each program to specific patients' needs, which is particularly important given that children with DCD have a widely ranging set and severity of symptoms (Blank et al., 2012).

The proposed research seeks to contribute to filling some of these gaps, by comparing the effect of task-oriented intervention program versus strength training in terms of improving motor proficiency in children aged 8-12 years with developmental coordination disorder in a randomized controlled pilot study.

1.3. RESEARCH QUESTIONS

The research study addressed the following research questions:

RQ1: Does the strength training intervention program has similar results in improving motor proficiency as the task-oriented program?

RQ2: Which type of the intervention program has better outcomes in terms of manual dexterity, balance, and ball skills?

RQ3: Which type of the intervention program has have higher compliance to treatment among 8-12 year-old children?

Chapter 2: Literature Review

2.1. DEFINITION

Developmental Coordination Disorder (DCD) is a chronic neuro-developmental condition that significantly affects the development of motor coordination and is not explicable in terms of general intellectual retardation or any specific congenital or acquired neurological disorder. Being diagnosed with DCD has been found to be associated with problems in language, writing skills, perception, learning and attention, daily activity and social life, personality and behaviour (Blank et al., 2012).

In 1987 the term “developmental coordination disorder” and the diagnostic criteria for DCD were added to the third edition of the Diagnostic and Statistical Manual of Mental Disorders (APAS, 1987), and Leeds Consensus Statement (Sugden, 2006) confirmed the agreement of international researchers and clinicians to retain the term “DCD”. In 2010, European Academy for Childhood Disability (EACD) recommended that the term “DCD” be used in countries that adhere to the DSM-IV classification and the term “Specific developmental disorder of motor functions” (SDDMF) in countries where ICD-10 has legal status.

At the same time, some other terms can still be found both in scholarly literature and among clinicians. These include “dyspraxia,” “clumsy child syndrome,” “sensory integrative dysfunction,” “physical awkwardness,” and “perceptual motor dysfunction” (Blank et al., 2012).

2.2. EPIDEMIOLOGY

Developmental Coordination Disorder has been recognized as one of the most common developmental dysfunctions in childhood (Blank et al., 2012). According to literature, the prevalence of DCD varies from 5-6% (American Psychiatric Association, 2013; Gaines et al., 2008) to 5-10% (Wilmut et al., 2007).

It is commonly believed by New Zealand health care professionals treating DCD that this number could be as high as 10%, but as of now insufficient studies have been conducted to confirm this number (Dyspraxia Support Group, n.d.).

DCD has been found to be more common among boys than girls, with male-female ratios varying from 2:1 to 3:1 (Blank et al., 2012).

2.3. AETIOLOGY AND PATHOGENESIS

Unfortunately, the aetiology and pathogenesis of the disorder are still unknown. The symptoms and their onset, progress, and co-morbidities vary, which makes defining aetiology difficult.

Seeking to explain the underlying mechanism behind the disorder, previous research has put forward two hypotheses (Zwicker et al., 2012).

The first one, referred to as the automatisation deficit hypothesis, views DCD as stemming from difficulties in making motor skills automatic (Fawcett, 1992) and therefore views DCD as having to do with the cerebellum.

The second, internal modelling deficit hypothesis, also views cerebellar involvement as being central to the development in DCD (Kageger, Bo, Contreras-Vidal, and Clark, 2004). However, it posits that unsuccessful motor control results from ineffective functioning of an internal model that forecasts the likely sensory effects of motor command (Krakauer & Shadmehr, 2007) and therefore treats motor difficulty as stemming from a mismatch in cerebellar motor signals.

Although the discussion about what exact mechanism could account for DCD is still open, previous research has often viewed it as being related to the functioning of the cerebellum (Canten, Polatajko, Thach, and Jaglal, 2007; Zwicker, Missiuna, and Boyd, 2009). A recent study by Zwicker and colleagues (2012) compared the structure of brains of children with and without DCD in terms of integrity of cerebellar, motor, and sensory pathways and found DCD patients exhibit significantly lower mean diffusivity of the posterior corticospinal tract and posterior thalamic radiation than healthy individuals. This led the research team to conclude that DCD may be explained by the microstructural development of sensory and motor pathways.

2.4. SIGNS AND SYMPTOMS

2.4.1. Diagnostic criteria

According to DSM-V, DCD is defined by the following four criteria (APA, 2013):

A. The acquisition and execution of coordinated motor skills is substantially below the expected level given the individual's chronological age and available opportunities for skill learning and use. Difficulties are manifested as clumsiness (e.g., dropping or 3 bumping into objects) as well as slowness and inaccuracy of motor skills performance (e.g., when catching an object, using scissors or cutlery, handwriting, riding a bike, or participating in sports

B. The motor skills deficit in Criterion A significantly and persistently interferes with activities of daily living appropriate to chronological age (e.g., self-care and self-maintenance) and impacts academic/school productivity, prevocational and vocational activities, leisure, and play

C. Onset of symptoms is in the early developmental period

D. The motor skills deficits are not better explained by intellectual disability (intellectual developmental disorder) or visual impairment and are not attributable to a neurological condition affecting movement (e.g., cerebral palsy, muscular dystrophy, degenerative disorder).

2.4.2. DCD and daily activities

DCD has a significant influence on daily activity life. Children experience difficulties with daily activities skills such as dressing (i.e., clothing themselves, fastening button or zips, tying shoelaces), eating, personal hygiene, spatial orientation (i.e., buttons in wrong holes, shoes on the wrong feet) (Missiuna, Moll, King, & Law, 2007; Bart, Jarus, Erez, &Rosenberg, 2011; Van der Linde et al. 2015; Summers, Larkin, & Dewey, 2008).

The two main reasons responsible for changes in daily activity life and participation in self-maintenance activities (such as dressing, bathing, teeth cleaning, and eating) that have been identified by both researchers and parents include a lack of postural control and motor coordination as compared with typically developmental children (Summers et al., 2008; Mandich, Polatajko, & Rodger, 2003).

Parents of children suffering from DCD also report that they have to find ways to help their children cope with those difficulties, for example, by putting kids' clothes on a bed that are to be worn to school the next day, providing children with clothing that do not need significant coordination skills, as well as verbal prompting and physical assistance (Summers et al., 2008).

2.4.3. DCD and sport and out of school time activities (OST)

Participation in leisure and sport activities has been identified as a major factor promoting community affiliation and therefore contributes to better socializing and a higher quality of life.

It is well known that children with DCD participate in sport and OST activities less (Bult, Verschuren, Jongmans, Lindeman, and Ketelaar, 2011; Jarus et al, 2001; Fong et al., 2011) than typically developed children of the same age. Evidence suggests (Jarus et al, 2001; Fong et al., 2011) that children with DCD not only tend to participate in physical activities less frequently, but also have limited variety of those activities, as well as prefer quieter and more socially isolated activities compared to children without DCD. Jarus and colleagues (2001) found that even mild motor disabilities have a significant impact on children's participation in OST activities.

In addition, as reported by Fong and colleagues (2011), the level of participation is significantly affected by a child's weight status, making it difficult for overweight or obese children with DCD to participate in physical activities, which may be explained by both the reduced physical fitness level and the social stigma associated with obesity (Puhl & Latner, 2007).

2.4.4. DCD and social life

Social participation is one of the most important part of people's lives. Children with DCD often experience social isolation (Mandich et al, 2003; Poulsen, Ziviani, Cuskelly, Smith, 2007). Negative self-image and failure to manage anxiety in social situations are often associated with DCD and may both been linked to social phobia (Hofmann, 2005).

Poulsen and colleagues (2007; 2008; Jarus et al., 2011) found coordination difficulties to be significantly associated with loneliness. Young children and teenagers with DCD have difficulties in communication with their peers and are often excluded from team sports games because of their lack of physical coordination. Stephenson & Chesson (2008) reported that bullying was a commonly identified problem among children with DCD.

Parents of children with motor skill deficits (''clumsiness'') also reported that their children are often left alone, are more introverted, get easily frustrated and lack social skills (Segal, Mandich, Polatajko, & Cook, 2002).

2.4.5. DCD and psychological problems

A recent meta-analysis of 41 articles has demonstrated that children with DCD tend to report lower self-efficacy and competence in physical and social domains, experience greater symptoms of depression and anxiety (Zwicker et al., 2012).

Stephenson and Chesson (2008) found children with DCD experience emotional problems that were described by their mothers as anger, frustration, unhappiness, distress, depression, low self-esteem, shyness, and embarrassment. These mothers also reported that the impact of those difficulties in their children affected the entire family, and at times the extended family as well.

Pearsall-Jone and colleagues (2011) examined pairs of twins and concluded that the levels of anxious and depressive symptomatology were significantly higher among twins with a motor disorder.

Psychological problems experienced by children with DCD have also been found to become more severe with time, progressing from motor and play concerns in early years, to self-care and peer problems in middle childhood, to significant challenges with self-esteem and emotional health in later childhood (Missiuna et al., 2007).

Even more so, these problems are carried over into adulthood, putting adults with DCD at a higher risk for social and psychiatric problems (Mandich et al., 2003).

2.5. ASSESSMENT

A number of assessment tools exist for diagnosing DCD, measuring movement ability, strength, balance, daily activity performance in children with DCD. Screening protocols most often used by health professionals and researchers to reveal and assess children with DCD are presented in Table 2.1.

2.5.1. Movement Assessment Batteries for Children

The Movement Assessment Batteries for Children are norm-referenced tests for children aged 4-12 years, split in four age groups (MABC), and children aged from 3 years to 16 years 11 months split in three age groups (MABC-2). Moreover, MABC-2 has different combinations of test items in each group.

MABC/ MABC-2 is considered to be the most appropriate test among available tests for assessing motor proficiency and is recommended as the preferable test with good-to-excellent test–retest reliability and fair-to-good validity (Blank et al. 2012; Bieber, Smits-Engelsman, Sgandurra, Cioni, Feys, Guzzetta, Klingels, 2016).

Intra-class correlation coefficient (ICC) was used in some studies investigating MABC reliability. For example, Croce and colleagues (2001) conducted MABC test with a sample of 106 boys and girls of 5–12 years old and found the values of the ICC to range from 0.92 (for children aged 9–10 years) to 0.98 (for children aged 5–6 years). Chow and Henderson (2003) assessed the reliability of M-ABC among 79 children aged 4–6 years and found ICC of 0.96 across items.

At the same time, a recent study that examined if MABC-2 could be a "gold standard" came to conclusion that it should not be utilized as a sole measurement tool for correctly diagnosing children with DCD (Venetsanou, Kambas, Ellinoudis, Fatouros, Giannakidou, Kourtessis, 2011).

Table 2.1.
Developmental Coordination Disorder screening protocols

Test / type	Aspects assessed	Duration/ scoring
Movement Assessment Battery for Children (MABC) and MABC-2/ experimental	• manual dexterity • ball skills • balance	20–30 min/ easy
Bruininks-Oseretsky Test of Motor Proficiency (BOTMP)/ (BOTMP-2) / experimental	• fine-motor skills • manual dexterity • bilateral coordination • balance • running speed and agility • upper-limb coordination • strength	40–60 min complete form/ complex 15–20 min short form/ complex
Developmental Coordination Disorder Questionnaire (DCDQ'07)/ questionnaire	• motor control during movement • fine motor and handwriting • general coordination	10-15 min/ easy

Sources: Blank et al. (2012); Chow & Henderson (2003); Croce et al. (2001); Deitz et al. (2007); Ellinoudis et al. (2011) Van der Linde et al. (2014); Venetsanou et al. (2011); Wilson et al. (2009).

2.5.2. Bruininks-Oseretsky Tests of Motor Proficiency (BOTMPs)

BOTMP and BOTMP-2 are standardized, norm-referenced tests of motor function with norms set for 4 to 21 years. The age norms have 4-month intervals for preschool children, half-year intervals for schoolchildren and 1-year intervals for adolescents above 14 years, with separate norms provided for each sex.

The BOTMP/BOTMP-2 shows good-to-excellent reliability, fairly good validity, good 8 specificities, but lower sensitivity than MABC (Blank et al. 2012; Deitz, Kartin, & Kopp, 2007; Bieber et al., 2016). Deitz and colleagues (2007) used Pearson product moment correlation coefficient to assess reliability of the BOTMP-2. The Inter-rater reliability coefficient was found to be over .90 for the Short Form and for all Complete Form subtests and composites with one exception (the Fine Motor Precision subtest, Adj. r = .86). Pearson product moment correlation coefficients for the Test-retest reliability exceeded .80 for the three age groups for the Total Motor Composite and the Short Form.

In order to examine validity of the measures, Deitz and colleagues (2007) conducted three studies and found that in all three studies, each clinical group had significantly lower scores ($p < .001$) than a non-clinical comparison group, thus confirming the ability of BOTMP-2 to distinguish between non-clinical groups and specific clinical groups. Findings were similar for both the Complete Form and the Short Form.

The authors also assessed the strengths and limitations of BOTMP-2 and concluded that the short form of the BOTMP-2 is clinically useful for assessing 6-21 year olds with suspected global motor delays. However, due to reliability limitations (see Deitz et al., 2007, Table 2.2.), authors suggest that therapists be cautious when using this test for determining a child's skill level in specific areas of motor development. Bieber and colleagues (2016) suggested that another test be used to assess hand dexterity for children with DCD — Purdue Pegboard Test (PPT). PPT is a norm-referenced test for children aged 5-18 years and is recommended by authors as having a relatively higher reliability and validity and fewer confounding variables, such as age, gender, and handedness (Causby, McDonnell, Hillier, 2014; Lindstrom-Hazel & Vander Vlies Veenstra, 2015).

Table 2.2.
Reliability and validity of some assessment tools for children with DCD

Test	Reliability			Validity
	Internal Consistency	Test-retest	Inter-Rater	Value
MABC-2 manual dexterity	Rc = .70–.87	ICC= .78–.85	ICC= .94–1.00	r = .48
BOT-2 fine manual control and manual coordination	Rc = .60–.92	ICC < .80	ICC < .90	r = .60
DCDQ'07	Rc = .94	ICC= .94–.97	-	-
ZNA fine motor adaptive task	-	ICC= .45–.66	ICC= .49–.71	r = .65
Purdue Pegboard Test	-	r = .68	ICC= .37–.90	r = .48-.67

Note: **Rc** - Cronbach's alpha; **Rp** - Pearson correlation; **Rs -** Spearman correlation; **ICC -** intraclass correlation coefficient; **r** - type of correlation not specified

2.5.3. Developmental Coordination Disorder Questionnaire (DCDQ-07)

DCDQ'07 is a questionnaire for children aged 5-15 years that is used to diagnose DCD. DCDQ'07 questionnaire is to be filled out by parents as individuals having the arguably best knowledge of their children and therefore the best ability to reliably report their children's developmental problems.

By design, the DCDQ'07 has been found to be the most accurate in identifying children who may have DCD (Wilson, Crawford, Green, Roberts, Aylott, & Kaplan, 2009). The overall sensitivity of DCDQ'07 is 84.6% (ranging from 75.0% to 88.6%) and the specificity is 70.8% 9 (66.7%-75.6%) (Wilson & Crawford, 2012).

2.5.4. Other assessment diagnostic tools

Several other tests for assessing motor functions have been used in research studies, such as Zurich Neuromotor Assessment (Kakebeeke, Egloff, Caflisch, Chaouch, Rousson, Largo, Jenni, 2014; Rousson et al., 2008), McCarron Assessment Neuromuscular Development (MAND) (McCarron, 2007). However, these tests have not been evaluated or have been found to demonstrate poor reliability, validity, specificity, and sensitivity (see Table 2.2.) (Bieber et al., 2016; Rousson, Gasser, Caflisch, Largo, 2008; Brantner, Piek, & Smith, 2009), which makes them inappropriate for usage in the proposed research study,

according to the established standards for rigorous research design (Bowling, 2014, pp. 166-168). It is for this reason that they are not discussed in greater detail here.

Bieber and colleagues (2016) suggested that another test be used to assess hand dexterity for children with DCD: Purdue Pegboard Test (PPT). PPT is a norm-referenced test for children aged 5-18 years and has been recommended in previous research as having relatively higher reliability and validity and fewer confounding variables, such as age, gender, and handedness (Causby, McDonnell, Hillier, 2014; Lindstrom-Hazel & Vander Vlies Veenstra, 2015).

2.6. INTERVENTION APPROACHES

Due to the existing lack of knowledge about the aetiology and pathogenesis of DCD, there is no unified approach and standards of treatment. The majority of intervention approaches could be divided into two groups: task-oriented and process-oriented intervention programs. Two recent reviews of effectiveness of intervention for children with DCD (Hillier 2007; Offor, Williamson, Caçola, 2016) both found intervention programs to be effective in terms of improving balance, coordination, muscle strength and function, and motor function. At the same time, the most recent of those reviews emphasized the lack of rigorous research studies and suggested that future researchers should explore the effectiveness of therapy modalities and their outcomes for children with DCD (Offor et al., 2016).

2.6.1. Task-oriented approach

Task-specific intervention focuses on problem solving and direct teaching of specific functional, meaningful skills, with the goal of optimizing movement efficiency and performance given an individual's abilities (Blank et al., 2012; Wilson et. al., 2005). Task-oriented frameworks are informed by the dynamical systems and the neural group selection theory and include functional, task-specific, and cognitive approaches.

Examples of training that apply the task-oriented approach include neuromotor task training (NTT), motor imagery training, and cognitive orientation to daily occupational performance (CO-OP; see Polatajko & Mandich, 2004; Missiuna, 2001). The evidence for the effectiveness of task-orientated interventions is more promising (Sugdon, 2006; Missiuna et al., 2006; Niemeijer, Smits-Engelsman, Schoemaker, 2007) than the process-oriented, with NTT having been formally included into a program of teaching physiotherapists in the Netherlands.

2.6.2. Process-oriented approach

The process-oriented approach in the context of intervention means that the treatment addresses components or body functions needed to perform activities. In the case of DCD, the underlying assumption is that the improvement of body functions, such as perception, sensory integration, muscle strength, and visual–motor perception, leads to better skill performance (Blank et al., 2012). Sensory integration therapy (SIT) (Leong, Carter, & Stephenson, 2015), kinaesthetic training (Laszlo & Bairstow, 1983; Sims, Henderson, Hulme, Morton, 1996), perceptual motor training (PMT) (Jonstone & Ramon, 2011; Milander, 2015) are the examples of the process-oriented approach.

Besides these intervention methods, another example of applying the process-oriented approach could be traditional physical therapy, such as strength training. Strength training has been found to improve balance and coordination as well as muscular strength and endurance (Kordi, Sohrabi, Kakhki, Hossini, 2016).

One of the more well-explored programs is a core stability training, which develops the muscles of the lumbopelvic and abdominal regions that provide stability of the spine during movement and during a change in posture (Bhayani & Singaravelan, 2012; Kane & Bell, 2009). This program potentially affects the lack of strength, coordination, and balance that children with DCD have, as core muscles are fundamental for developing awareness of position and movement. They were some research that have been studied strength training program (see Table 2.3). The major outcomes were improvement of the trunk stability, balance, physical skills (running, jumping, hopping), the level of participation through the promotion of muscular capacity (strength and endurance) and improved recruitment at the level of neural control.

2.6.3. Comparing of the effectiveness of approaches

There is a lack of studies that would compare different approaches to the treatment of children with DCD in terms of influence on motor proficiency. Only those study that compared different approaches and where motor skills of children with DCD were assessed are reported in Table 2.4.

A preliminary search of the literature that was conducted as part of preparing this literature review revealed as few as one study (Au, Chan, Lee, Chen, Chau, & Pang 2014) that compared the effectiveness of core stability exercise program (mainly on Swiss ball) and task-oriented motor training. Au and colleagues (2014) held a randomized controlled pilot

trial by allocating twenty-two children diagnosed with DCD aged 6-9 years in two different groups. BOT-SF and Sensory Organization Test (SOT) were used as main measures in the pre- and post-interventions. Both groups completed a 8-week program of face-to-face sessions once a week, complemented with a program of exercises performed at home. The comparative analysis of the results in the two groups found the two programs to be equally effective in improving motor proficiency among children with DCD.

However, there were several limitations of this study. First of all, BOT-SF and SOT were used as the main assessment tools, even though they are not considered to be the "gold standard" for DCD and have not been recommended by EACD to be used in clinical studies. Moreover, only the total score for BOT-SF was counted without specifying scores for subtests. Secondly, the study relied on a small group (N=22) of children of a rather narrow age range of 6 - 9 years old.

These limitations notwithstanding, the results showed that the training programs used in this study are feasible, and the outcomes are quite promising, making Au and colleagues' (2014) findings an important contribution to the DCD treatment approaches that raised theoretically useful questions that need further discussion and research.

Table 2.3.
Studies examining the effectiveness of strength training intervention programs

Author (year)/ Country	Participants (number, age, sex)	Study design	Assessment tools	Type of exercises	Frequency & duration of intervention	Findings
Kordi et al. (2016)/ Iran	N: 30 A: 7-9 yrs S: M & F	RCT IG: Strength training group CG: Routine exercises in physical education class	BOT-2 HHD (isometric strength of hip abductor muscles/ plantar flexors)	IG: Theraband elastic exercises: - leg abductors - leg adductors - knee flexion - knee extension - bridging - bilateral heel raises	• 2 sess/week • 60 mins • 12 weeks	• Muscle strength significantly increased ($p < 0.001$) • Static balance performance improved ($p < 0.05$) • No significant impact on the dynamic balance performance ($p > 0.05$)
Kane & Bell (2009)/ Canada	N: 3 A: 9-11 yrs S: M& F	Case Study	DCDQ-07 BOTMP-SF COPM CSAPPA CSS	Core Stability: exercises to increase strength of key trunk and hip muscles + Task-Specific Intervention: teaching of age-appropriate sport skills	• 2 sess/week • 6 weeks • home exercise program	• Improved static balance • Increased core muscles strength • Improved jumping, running skills • CSAPPA increased
Bhayani & Singaravelan (2012)/ India	N: 30 A: 6-16 yrs S: M & F	RCT IG: Strength training + Task- training exercises CG: Task-training exercises	DCDQ-07 BOTMP-SF CSAPPA FPFHS	IG: Core stability (bird dog, plunk, hip bridge, roll up with a ball, single leg bean bag kick) + Task-Specific Intervention (teaching of age-appropriate sport skills) CG: Task-Specific Intervention	• 2 sess/week • 6 weeks • 55 mins	Change scores[post-pre] • BOTMP-SF IG: 24.38± 6.911 CG: 2.928± 1.639 • CSAPPA IG: 15.923± 8.261 CG: 5.714 ±1.637 • FPFHS IG enhanced motivation and increased in task-specific confidence for physical activity more than CG

Note: **A** - Age of Participants; **BOTMP-SF** - Bruininks-Oseretsky Test of Motor Proficiency (Short Form); **CG** -Control group; **COPM** - Canadian Occupational and Performance Model; **CSAPPA** - Children's Self - Perceptions of Adequacy in and Predilection for Physical Activity; **CSS** - Core Stability Screen; **F** - female.
FPFHS - Five Point Facial Hedonic Scale; **HHD** - Hand-held Dynamometer; **IG** - Intervention Group; **M** - male; **MABC-2** - Movement Assessment Battery for Children-2; **N** - Number of Participants; **RCT** - Randomized Controlled Study; **S** - Sex of Participant

Table 2.4.
Studies comparing different approaches to DCD treatment

Author (year)/ Country	Intervention program	Participants (number, age, sex)	Study design	Assessment tools	Frequency & duration of intervention	Type of exercises	Findings
Au et al. (2014)/ China	Core stability exercises vs task-oriented motor training	Core stability N = 11 A = 8.1 ±0.1 yrs B:G = 7:4 Task-oriented motor training N = 11 A = 7.6 ± 1.0 yrs B:G = 8:3	RCT	BOTMP-SF SOT	Both groups: 8 weeks 1 ses/week 60 mins	Core stability group: -exercises on major trunk muscle groups -main tool-swiss ball Task-oriented group: -exercises with varying speed, direction, visual direction, and surfaces -adding environmental features for body orientation -performing the task in a moving and constantly changing environment	- The increase in motor proficiency was similar after core stability training and task-oriented motor training among children with DCD -Attendance rate and compliance to home exercising did not show any significant differences -Composite equilibrium score significantly improved in the task-oriented group, but not in the core stability group
Ferguson et al. (2013)/ South Africa	NTT vs Nintendo Wii Fit training	NTT N=27 A=8.22+-1.34 yrs B:G = 15:12 Wii N=19 A=7.63 +-1.07 yrs B:G = 9:10	Q-E; single blinded	MABC-2 FSM HHD MPST 20mSRT	NTT - 9 weeks 2 sess/week 45-60 mins Wii - 6 weeks 3 sess/week 30 mins	NTT - outdoor games Nintendo Wii Fit training - mainly incorporated with balancing games	- NTT group: improved manual dexterity, balance as compared to Wii Fit -Wii Fit: balance component improved, but not was not statistically significant -No significant changes found for group, time or time x group in Aiming and Catching found

Note: **A** - age of participants; **B:G** - boy:girl ratio; **BOTMP-SF** - Bruininks-Oseretsky Test of Motor Proficiency (Short Form); **FSM** - Functional Strength Measure; **HHD** - Hand-held dynamometer; **MABC-2** - Movement Assessment Battery for Children-2; **MPST** - Muscle Power Sprint Test; **N** - number of participants; **NTT** - Neuromotor Task training; **Q-E** - quasi-experimental; **SOT** - Sensory Organization Test; **20mSRT** - 20 Metre shuttle run test

2.7. CONCLUSION

The most recent of the relevant review articles on DCD emphasized the lack of rigorous research studies and suggested that future researchers should explore the effectiveness of therapy modalities and their outcomes (Offor et al., 2016).

The significance of the proposed research is threefold. First, it addresses a knowledge gap in present scholarship by directly comparing the effectiveness of a strength program (based on the process-oriented approach) and a task-oriented motor program (based on the task-oriented approach) in improving motor proficiency of children with DCD. Secondly, the proposed research contributes to identifying more effective ways to improve various facets of motor skills (manual dexterity, balance, and ball skills). Finally, it contributes to finding more patient-friendly intervention programs for 8-12 years old children.

Chapter 3: Research Design

3.1 METHODOLOGY AND RESEARCH DESIGN

3.1.1. Study Design & Setting

The study was designed as a randomized controlled trial. Participants were randomly assigned into two groups. The first group underwent a task- training program (n=9), the second one (n=9[1]) performed a strength- training program.

The study took place in three settings, the Biokinetic Clinic at Waikato Institute of Technology and two primary schools (Knighton Primary School and Hamilton East Primary School) in Hamilton, Waikato region. Recruitment was conducted through schools and occupational therapy services.

3.1.2. Ethics

As the research project had participants undergo a fitness testing and exercise rehabilitation program, the study was submitted for approval to the Ethics Commission of Wintec Research Office. The letter of approval from the Ethics Commission is in Appendix 1.

All potential participants of the study and their parents were provided with detailed information about the project, including information about risks, benefits, and the type of feedback to be provided once the project would be completed (see Appendices 2 and 3). Full consent from parents was obtained prior to the study (see Appendix 4).

The participation in the study was voluntary and participants could withdraw from taking part at any time if they wished to do so. This information was also provided in the information leaflets for kids and their parents.

All information about participants was kept confidential, with the name and any other identifiable information not to be published or publicly referred to elsewhere. For this reason,

[1] The initial number of children assigned to the strength-training group was 11, of whom nine completed the program.

all the participants are referred to hereafter by the generic name "Participant," followed by an ID number they were assigned at the point of recruitment.

3.1.3. Recruitment

The recruitment of participants was carried out through teachers and healthcare professionals. At the first stage, information leaflets (see Appendix 5) were emailed to schools and occupational therapy (OT) services, after which the following steps were taken, depending on the entity involved:

Schools: Upon the receipt of the leaflets, schools were asked to share information about the project with parents. This was done in two ways, at the schools' discretion. In some schools, class teachers identified possible DCD candidates according to the guidelines laid out in the leaflets. Parents of those children were then contacted by a class teacher or a deputy principal, who provided them with information about the research study and the researcher's contact details. The alternative way for distributing information was posting the recruitment announcement in schools' newsletters, with the invitation for interested parents to contact the researcher via email or phone.

Occupational therapists: All occupational therapists were provided with the researchers' contact information and were asked to inform parents, once they had identified any eligible study participants. The parents then contacted the researcher directly by email.

An attempt was also made to recruit participants through the Waikato DHB Child Development Centre. However, upon discussing this possibility with the Centre staff, it became clear that the Centre is working exclusively with children diagnosed with a concomitant pathology, an excluding criterion in the study. That is why the decision was made not to recruit children through the Waikato DHB.

Once the initial contact with parents was established, those parents who indicated an interest to participate in the study but had not received the information leaflets, were provided with the copies of the information leaflets for parents and children. A week later, parents were contacted again. If they were interested in participation, parents and children had a face-to-face interview with the researcher at the Biokinetic Clinic or at school. This gave the opportunity to the children and parents to discuss the details of the follow-up testing and project in general, as well as to ask questions they might have. During this meeting, parents

filled out a DCDQ-07 questionnaire and signed a consent form. In some occasions, when parents were not able to meet with the researcher personally due to a scheduling conflict or some other reason, they were sent the DCDQ-07 questionnaire and the consent form by email.

If the DCDQ-07 score based on the analysis of the questionnaire data met the DCD criteria, a child and his/her parents were invited to an assessment session, during which the child was tested using the MABC-2. If the DCDQ-07 score did not meet the DCD criteria, parents were informed that child did not meet the eligibility criteria and were thanked for their responsiveness.

As soon as a child had completed the test, data were analysed, and the final decision whether to include the child in the study was taken. After that, a child was randomly assigned to either treatment group. An online random number generator (https://www.random.org/) was used to assist in randomisation process.

A total of 20 children were recruited between July and September 2017, assigned to the groups of 9 (task-oriented) and 11 (strength training). In the course of the program, two children dropped from the study, which left the researcher with a total of 18 participants (9 children per group).

The stages of the recruitment process are presented in Figure 3.1.

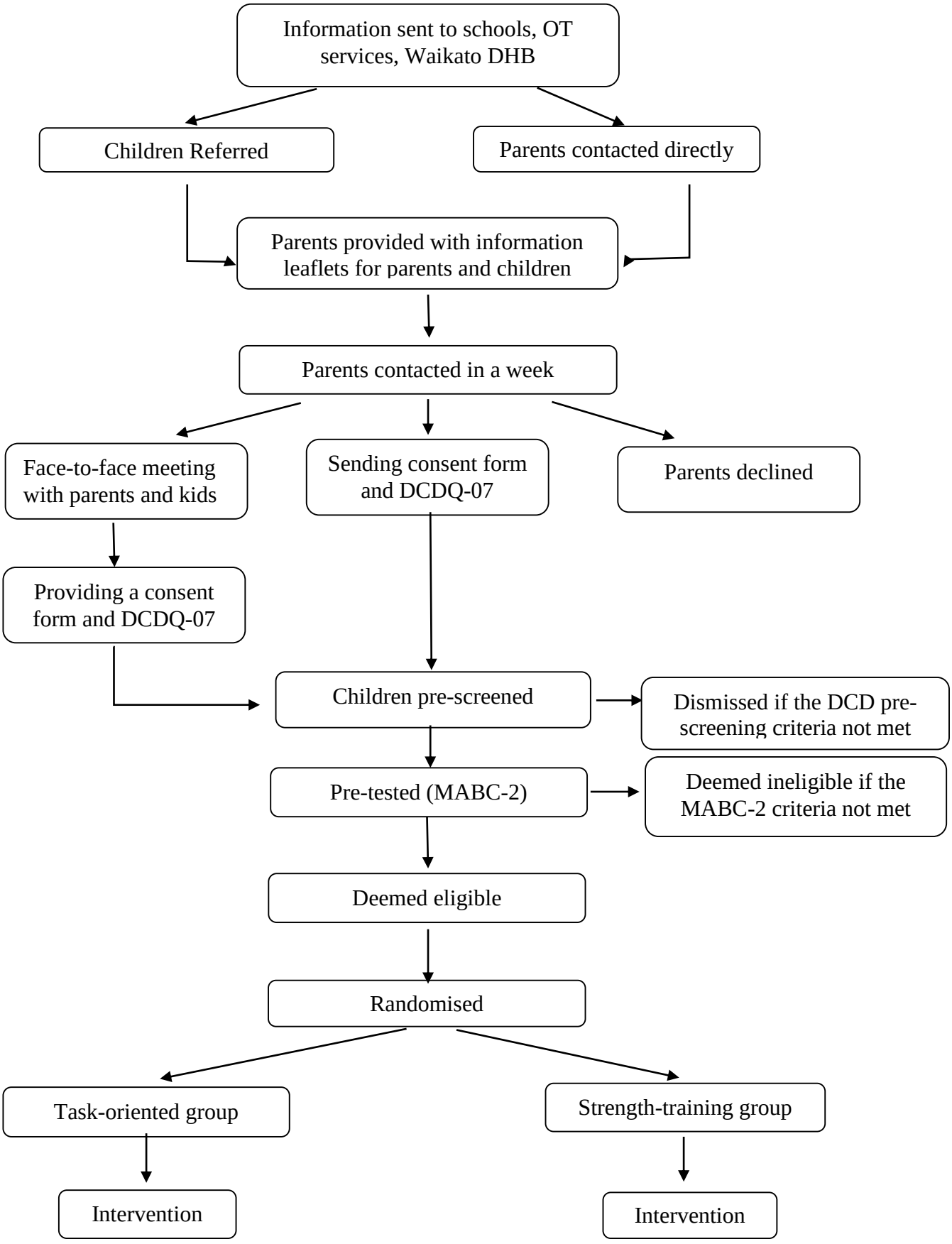

Figure 3.1. ***Stages of the recruitment process***

3.1.4. Sampling

Initially 23 schools in Hamilton were sent an information leaflet with an invitation to take part in the project, followed up by a meeting with a schools' principal or deputy principal. Seven schools agreed to participate. In three schools, teachers contacted the parents of 4-6 grade children who displayed DCD symptoms as laid out in leaflets for teachers. The four remaining schools chose to distributed information about research by posting it in the school newsletters. Parents who were interested in participation then directly contacted the researcher.

Out of the three occupational therapists contacted, one agreed to participate in the study and referred two children as a result.

For participation in the project, children of both genders were selected. The age frame was 8 yrs. 0 months – 11 yrs. 11 months, chosen to correspond to the age of a primary school 4-6th-grader.

3.1.5. Eligibility Criteria

In order to be considered eligible for the trial, individuals had to comply with the following inclusion criteria:

● Male and female children aged 8 yrs. 0 months – 11 yrs. 11 months

● Have a total test score at or below the 15th percentile on the Movement Assessment Battery for Children (MABC-2)

● Have a total score of 15-57 on the Developmental Coordination Disorder Questionnaire-2007 (DCDQ-07)

3.1.6. Exclusion Criteria

The exclusion criteria were as follows:

● Children with a total score above the 15th percentile on MABC-2

● DCD children with mental retardation

● DCD children with any congenital cardio-respiratory condition, congenital musculoskeletal condition

● DCD children with severe visual and/or hearing disability preventing them from completing exercises prescribed by either program

● Children with behavioural difficulty making them unable to complete exercises prescribed by either program

3.2 ASSESSMENT

As soon as children had been deemed meeting the eligibility criteria and all preparatory work had been completed, children were invited to assessment sessions. Assessments took place at the Biokinetic Clinic at Wintec and at schools. Parents were invited to be present during the assessment session if they chose to do so. The assessments lasted about 60 minutes each and were conducted by the researcher.

3.2.1. Pre-screening

The DCDQ-07 questionnaire was used for screening purposes, as a tool providing the optimal combination of user-friendliness and reliability despite its self-reported nature.

3.2.1.1. Developmental Coordination Disorder Questionnaire - 2007 (DCDQ-07)

DCDQ-07 has been chosen as a measurement tool as providing the best combination of user-friendliness and demonstrated reliability despite its self-reported nature and was used in the study for screening purposes.

The DCDQ-07 questionnaire was filled out by parents as possessing arguably the best knowledge of their children as compared with other individuals and therefore having the best ability to reliably report their children's developmental problems. Despite its self-reported nature, previous research has found DCDQ-07 to be the most accurate pre-screening tool for identifying children who may have DCD (Wilson, Crawford, Green, Roberts, Aylott, & Kaplan, 2009).

3.2.3. Primary outcome measure

With MABC-2 being recommended by EACD as the motor assessment test producing the most reliable and valid results (Blank et al., 2012), the Researcher chose to use it as the primary diagnostic tool in the project. In addition to the demonstrated validity, MABC-2 is quicker to set up, administer and score as compared with more time-consuming tests, such as BOT-2, and requires minimal training.

3.2.3.1. Movement Assessment Battery for Children (MABC-2)

The MABC-2 is designed to identify and assess the severity of the coordination and balance impairments in motor skills of children and adolescents and has been validated in previous research by using a large representative normative sample (Blank et al., 2012).

MABC-2 contains 8 subtests in three domains: manual dexterity, aiming and catching, and balance. It includes different tasks for three age bands: 3-6 years, 7-10 years, 11-16 years. Given the age of the study participants, the second and third age bands were applied.

7-10 years age band: The manual dexterity subtest involves three separate tasks: (1) drawing a line within a printed pattern, with the number of mistakes counted; (2) timed peg-placing test, with the speed of completing the task recorded (both hands are tested); (3) threading task using a piece of lace and a plastic board with holes. The best result out of two trials is recorded.

The aiming and catching subtest involves two separate tasks: (1) the aiming task has a child stand 1.8 meters from a target mat attempting to throw a beanbag into a defined red mark on the mat (the number of correctly executed throws out of 10 is recorded); (2) for the catching task, a child stands 2 meters from a wall and throws a tennis ball against the wall, attempting to catch the ball without trapping it against the body with two hands (the number of correct catches out of 10 is recorded).

The balance subtest has three tasks: (1) hopping on one leg across 5 mats; (2) standing on a balance board as long as a child can (maximum time is 30 secs); (3) walking forward heel-to-toe along a 4.5-meter line on the floor marked with a tape. Each test has a practice trial and two actual trials, with the best out of two attempts recorded.

11-16 years age band: The manual dexterity subtest involves three tasks: (1) inverting 12 pegs, timed (both hands are tested); (2) constructing triangles from perforated plastic strips with nuts and bolts; (3) drawing a line within a printed pattern. The best result out of two trials is recorded.

The aiming and catching subtest includes two tasks: (1) catching a ball with one hand standing 2 meters from a wall (both hands are tested); (2) aiming a red target at the wall standing 2.5 meters from the wall. Number of successful hits out of ten throws is recorded.

The balance includes three subtests: (1) static balance is tested by timing a child balancing on two balance boards; (2) dynamic balance is assessed by having a child walk backward toe-to-heel along a 4.5-meter line and zigzag hoping on 5 mats. A child has two attempts for each of these tests, with the best result written down.

The raw scores from each domain were then transformed into standard scores and added to ascertain the total test score, which ranges from 0 to 40 (Henderson & Sugdon 2007). Normative data are available for each age from the Examiner's Manual (2007). The total test score was then used to calculate the overall movement difficulty percentile. According to the Examiner's Manual (2007), a child with score below the 5th percentile is considered to have a definite movement difficulty. Those whose score below the 15th percentile are deemed to be at risk of movement difficulty, and child with score above the 15th percentile is considered a healthy child without disorder.

3.2.4. Secondary outcome measures

3.2.4.1. Home exercise enjoyment scale for children

The home exercise enjoyment scale for children utilized the images of smiling faces (smileys) as measurements units, which children had to circle themselves to indicate their level of enjoyment from the home exercise. Pictures with smileys were included in each home exercise program sheet and had five faces, with captions ranging from "Absolutely No" to "Yes!". The scale was then converted into a 5-point Likert scale (from 1= "Absolutely No" to 5 = "Yes!"), with greater values corresponding to a greater level of enjoyment.

3.2.4.2. Post-intervention interviews with parents

A post-intervention parent interview questionnaire had three bands of questions. The first one asked if a child had enjoyed exercise sessions delivered in the Clinic or at school. A five-point Likert scale was used, with answers, 1= "Strongly agree", 2= "Agree", 3= "Neither agree nor disagree", 4= "Disagree", 5= "Strongly disagree". The second and third bands contained questions about the enjoyment and encouragement needed during home exercises, asking parents to indicate, on a 5-point Likert scale, how often a child seemed to be enjoying the exercises and how often the child needed parental encouragement to complete the exercises, with response options, 1= "Always", 2= "Usually", 3= "Sometimes", 4= "Rarely",

and 5= “Never”. A copy of the post-intervention parent interview questionnaire is presented in Appendix 6.

3.2.5. Controls

3.2.5.1. Height

Height was measured in centimetres using a standard Seca 206 Body measuring tape with wall stop. Children were instructed to take their shoes off and to stand close to the wall with feet together and arms along the body, so that their head, upper back, buttocks and heels were touching the wall. Once positioned this way, children were then asked to look straight ahead, take a deep breath in and out. The height reading was then taken three times, with the average result recorded.

3.2.5.2. Weight

Weight was measured in kilograms using a standard Seca scales. Children were asked to wear light clothes and to remove their jackets and shoes. Three measurements were then taken and averaged.

3.2.3.3. Body Mass Index (BMI)

Body Mass Index (BMI) was expressed in kg/m^2 and was calculated by using the standard formula of dividing the weight by the height squared.

3.3. ORDER OF TESTING

Testing was conducted in a standardised manner. All testing was done by the researcher, using the same equipment tools. Firstly, measures of height and weight were done, then MABC-2 test was run. Appendix 7 presents the assessment form used for recording results.

3.4. INTERVENTION

The intervention programs consisted of 45-minute weekly sessions that were held during an 8-week period either in groups of two or individually at the Biokinetic Clinic at Wintec or at schools.

In addition, each group completed a home exercise program over the course of eight weeks, with exercises varying from week to week (eight weekly sets in total). Each intervention group had its own exercises, according to the type of the intervention program it has been assigned to.

3.4.1. Exercise sessions

An 8-week programme was chosen to optimize attendance and the subsequent effects of the intervention. Exercise intervention is a new approach to DCD treatment in New Zealand, so it was difficult to project the compliance levels of children and parents to the new method. In previous studies it was shown that during 6-10-weeks intervention period improvements in motor ability were successfully achieved, and frequency of sessions varied from once to twice per week (Peens, Pienaar, and Nienaber, 2008; Pless, Carlsson, Sundelin, and Persson, 2000; Kane & Bell, 2009; Hung & Pang, 2010; Bhayani & Singaravelan, 2012; Au et al., 2014). In addition, 8 weeks of the intervention is a reasonable period as school term lasts 10 weeks and 2 weeks are needed for assessment (pre- and post-testing) sessions.

The dates and time for sessions were discussed with parents during the assessment session and stayed the same over the course of intervention. An explicit attempt was made to make it clear to the parents that full attendance was crucial to ensuring the maximum benefit from participation in the program.

Exercise sessions were held either individually or in groups of two. It was originally planned to hold sessions exclusively in groups, but a number of children found it too uncomfortable to exercise in groups, which was explained by their parents as stemming from their lack of confidence and communication skills. In contrast, some children did prefer exercising in groups. Given the results of previous research that found no statistically significant differences among group and individual sessions in terms of their effect on motor skills (Hung & Pang, 2010), it was decided to conduct both individual and group sessions, leaving the choice to the children's discretion. To account for the possible effect of the mode of delivery (individual vs. group), the latter was statistically controlled for in subsequent data analysis reported further.

The task-oriented training program included exercises aimed at improving the following groups of skills:

- Balance
- Agility
- Proprioception
- Ball catching and aiming
- Coordination
- Fine motor skills

The strength- training program included the exercises targeted at the following:

- Core strength
- Upper-body strength
- Lower-body strength

Each exercise session consisted of warm-up (about 5 mins), workout (30-35 mins) and cool-down (about 5 mins) parts. The warm-up (warm-up exercise for big joints) and cool-down (stretching) parts had the same exercises for both groups. The exercises included in the supervised portions of the intervention programs did not change from session to session, but their intensity, number of repetitions and sets steadily increased over time. The program descriptions are presented in Appendices 8 (task-oriented group) and 9 (strength training group).

Attendance of the supervised sessions was taken by the researcher.

3.4.2. Home program

Home programs had eight different sets of exercises, one for each week and did not have a limit with regards to the number of repetitions and sets, so all participants could choose their own exercise pace. Each week, at the end of the supervised exercise sessions, the Researcher demonstrated a home exercise set and had a child perform 2-3 repetitions to make sure that everything was clear to a child.

At the beginning of the programme, each child and his or her parents were provided with a home exercise logbook (see Appendix 10) and instructions for completing it (Appendix 11). The logbook was printed in colour and included information about whether or not an exercise was completed, the number of repetition and sets as well as the home exercise enjoyment scale. Children were instructed to complete the logbook every day, excluding the day of a supervised exercise session at the Clinic/School. Parents were given instructions how

to help their children and recommendations about the ways to encourage the children, if needed.

3.5. RETESTING

One week after completing the 8-week intervention exercise program (during the week when the last home exercise was completed) all children from both the task-oriented and strength training program were retested. All tests were performed in the same sequence as during the baseline testing. The same assessment tools were used and the Researcher conducted all tests.

Parents were asked to fill out a post-intervention parent interview questionnaire and to leave their own comments if they were willing to share them.

3.6. ANALISYS

The data for statistical analysis of the motor proficiency changes were collected using the pre-test and post-test assessment of MABC-2 for both intervention groups. The statistical analysis was conducted using a series of one-way ANOVAs and paired t-tests.

The data obtained from the Post-intervention parent interviews and Home exercise enjoyment scale (filled out by children) were treated as quantitative. The number of responses was recorded and presented in percentages. The statistical analysis was conducted using one-way ANOVA. Multiple linear regressions were used to study whether contextual and child-related characteristics influenced the treatment outcome.

Chapter 4: Results

4.1. RECRUITMENT

The recruitment and group allocation processes are outlined in Figure 4.1. Initially, twenty-four children were considered for participation in the study. After screening and testing, 20 children were recruited.

Fifteen children were referred by school teachers and an occupational therapist. The occupational therapist referred two children, both of whom were found eligible and were enrolled in the study. Out of the remaining thirteen children referred by the school teachers, three were found ineligible and were subsequently excluded; the parent of one child, after receiving an informational leaflet, chose not to participate in the study, without elaborating on the reason for her decision.

Nine children were referred by their parents who got interested in the study by either reading about it in a school newsletter (7 children) or learning about it by the word-of-mouth, from their acquaintances from among school employees (2 participants). All of those children were found eligible for participation and were subsequently enrolled in the study.

From the children who were deemed ineligible, one child had intellectual disability, and one was hearing-impaired, which made them unable to take part in exercise sessions. One child was found ineligible because, according to the MABC-2 test, he had a score and percentile rate that corresponded to the normal values.

4.2. RANDOMISATION

After the pre-screening and testing sessions, 20 children were randomly assigned into two groups, using an online random number generator available at https://www.random.org/, with the task-oriented group assigned number 1, and the strength training group – number 2.

Randomized this way, 9 children were assigned to the task-oriented group and 11 children – to the strength training group. Of those, one participant in the strength training group had to drop from the study because his family moved to another city. Yet another child from the strength training program group dropped from the study after finishing as few as three exercise sessions and not completing any of the home exercises. Her data were therefore not included in subsequent analysis.

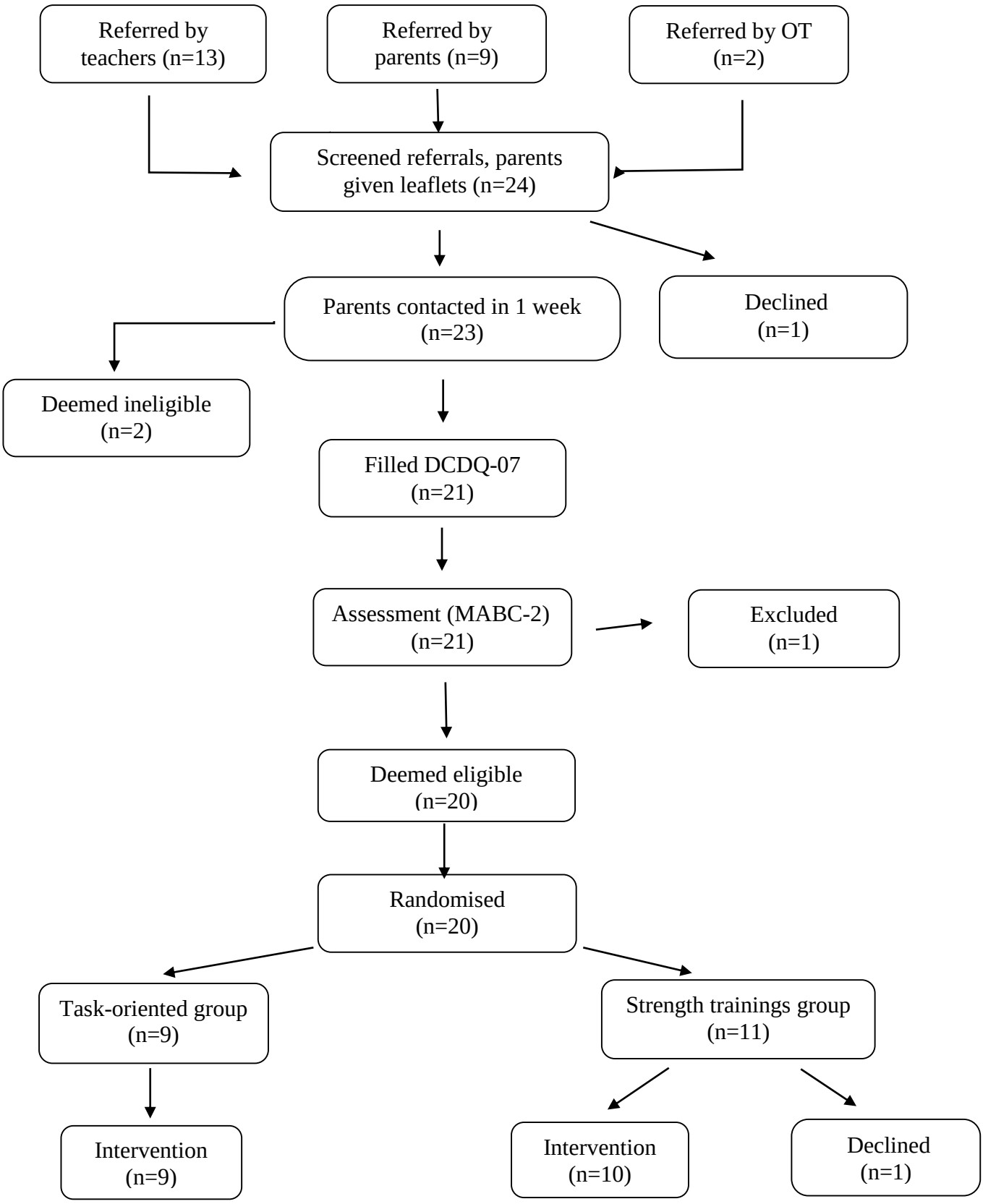

Figure 4.1. ***Recruitment: number of participants at each point of the process***

4.3. PRE-SCREENING: DEVELOPMENTAL COORDINATION DISORDER QESTIONNARIE – 2007 (DCDQ-07)

As previously mentioned in Chapter 3, DCDQ-07 was used as a pre-screening tool. Parents/whanau who were interested in enrolling their child in the research project, filled the questionnaire. If the total score was less or equal 57, children were invited for further assessment with a MABC-2 scale.

Although the task-oriented group had a slightly higher total score (M = 38.0, SD = 12.1) than the strength training group (M = 33.1, SD = 8.1), a one-way ANOVA found the differences between the group means to be non-significant (F (1,17) =1.011, p=.33), indicating that the randomization in terms of DCDQ-07 was successful.

4.4. BASELINE CHARACTERISTICS (CONTROLS)

The baseline demographics of the participants who completed the treatment (n=18) are presented in the Table 4.1.

The age of the children ranged from 8 to 12 years old, which meets the inclusion criteria discussed in Chapter 2. The boys-to-girls ratio was 2:1, which corresponds to the global DCD statistics (Blank et al., 2012).

The task-oriented group consisted of both girls (66.7%; n=6) and boys (33.3%; n=3); the strength trainings group consisted of boys (100%; n=9).

Overall, the majority of the children had low weight (55.5%; n=10), 38.8% (n=7) had normal weight, and 5.5% (n=1) were overweight, using the NHS National Obesity Observatory guidelines on BMI percentiles (2006).

Table 4.1.
Baseline characteristics of study participants (n=18)

	Male	**Female**	**Mean Age (SD), months**	**Mean BMI (SD), kg/m^2**	**Normal Weight, % (n)**	**Low Weight, %, (n)**	**Overweight**
Task-oriented group	3	6	113.89 (13.2)	17.3 (3.3)	33.3% (3)	66.7% (6)	-
Strength training group	9	0	112.89 (11.2)	18.5 (3.6)	44.4% (4)	55.5% (4)	11.1% (1)

Given that, according to the Examiner's Manual (2007), "no significant gender difference emerged for the Total Motor Score," the gender differences between the two groups was not viewed as potentially affecting MABC- 2 as the primary outcome measure.

4.5. PRIMARY OUTCOME MEASURE: MOVEMENT ASSESSMENT BATTERY FOR CHILDREN (MABC-2)

The inclusion criteria in terms of MABC-2 was the Total test score at or below the 15th percentile, which corresponded to the raw total test score equalling to or being lower than 67. In this section only baseline results of both intervention groups are presented.

MABC- 2 test was conducted by the Researcher in the Biokinetic Clinic or at schools, using the same equipment. Each child was tested during the same testing session. Testing time varied from 25 to 40 mins and occasionally included 1-3-minute breaks, if a child needed them.

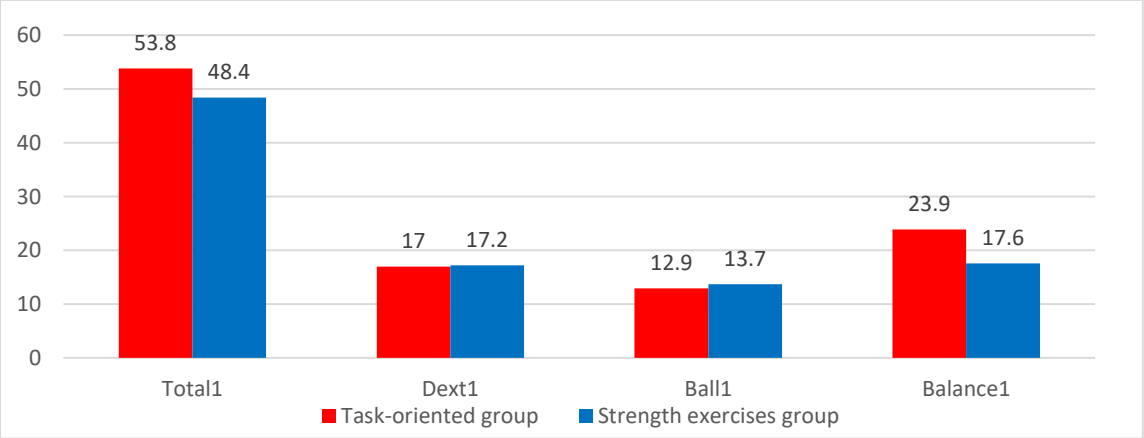

Figure 4.2. ***Comparison of the baseline average raw total test score, manual dexterity, ball skills, and balance***

The baseline values for total test score (Total1), manual dexterity (MD1), aiming and catching skills (Ball1), and balance (Balance1) have been recorded and analysed separately for each group. Figure 4.2 presents the mean scores for all the variables for both groups.

Mean scores and standard deviations of the total score, manual dexterity, ball skills, and balance for each exercise group are presented in Table 4.2.

Table 4.2.
Mean and SD volumes of the score bands for task-oriented and strength training group

	Task - oriented group		Strength training group	
	Mean	**SD**	**Mean**	**SD**
Total Score	53.78	10.414	48.44	10.370
Manual Dexterity	17.00	5.123	17.22	5.911
Ball skills	12.89	3.100	13.67	2.500
Balance	23.89	5.754	17.56	5.681

4.6. STATISTICAL ANALYSIS OF THE BASELINE VARIABLES

In order to analyse the effectiveness of randomization, a series of one-way ANOVAs were run to determine whether there were any statistically significant differences between the intervention groups in terms of the means of their baseline variables: Age, BMI, MABC-2: Total test score (Total), Balance, Ball skills (Ball), Manual Dexterity (MD), and DCDQ- 07. The results are presented in Table 4.3. (a,b).

According to the results, on all the variables but Balance (p=.032), the groups did not have statistically significant differences. To account for the possible effect of the baseline level of Balance, it was statistically controlled for in the linear regression analysis reported further.

Table 4.3. Between-group analysis of the baseline data

a) Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
Age	Task group	9	113.89	13.233	4.411	103.72	124.06	96	137
	Strength group	9	112.89	11.241	3.747	104.25	121.53	102	136
	Total	18	113.39	11.922	2.810	107.46	119.32	96	137
BMI	Task group	9	17.2778	3.30143	1.10048	14.7401	19.8155	14.10	22.10
	Strength group	9	18.5444	3.75304	1.25101	15.6596	21.4293	14.20	25.00
	Total	18	17.9111	3.49030	.82267	16.1754	19.6468	14.10	25.00
Total	Task group	9	53.78	10.414	3.471	45.77	61.78	31	66
	Strength group	9	48.44	10.370	3.457	40.47	56.42	27	61
	Total	18	51.11	10.448	2.463	45.92	56.31	27	66
MD	Task group	9	17.00	5.123	1.708	13.06	20.94	9	24
	Strength group	9	17.22	5.911	1.970	12.68	21.77	5	22
	Total	18	17.11	5.368	1.265	14.44	19.78	5	24
Ball	Task group	9	12.89	3.100	1.033	10.51	15.27	10	17
	Strength group	9	13.67	2.500	.833	11.74	15.59	9	18
	Total	18	13.28	2.761	.651	11.90	14.65	9	18
Balance	Task group	9	23.89	5.754	1.918	19.47	28.31	10	30
	Strength group	9	17.56	5.681	1.894	13.19	21.92	8	27
	Total	18	20.72	6.433	1.516	17.52	23.92	8	30
DCDQ-07	Task group	9	38.00	12.155	4.052	28.66	47.34	21	57
	Strength group	9	33.11	8.069	2.690	26.91	39.31	26	49
	Total	18	35.56	10.320	2.432	30.42	40.69	21	57

b) ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Age	Between Groups	4.500	1	4.500	.030	.865
	Within Groups	2411.778	16	150.736		
	Total	2416.278	17			
BMI	Between Groups	7.220	1	7.220	.578	.458
	Within Groups	199.878	16	12.492		
	Total	207.098	17			
Total	Between Groups	128.000	1	128.000	1.185	.292
	Within Groups	1727.778	16	107.986		
	Total	1855.778	17			
MD	Between Groups	.222	1	.222	.007	.933
	Within Groups	489.556	16	30.597		
	Total	489.778	17			
Ball	Between Groups	2.722	1	2.722	.343	.566
	Within Groups	126.889	16	7.931		
	Total	129.611	17			
Balance	Between Groups	180.500	1	180.500	5.521	.032
	Within Groups	523.111	16	32.694		
	Total	703.611	17			
DCDQ-07	Between Groups	107.556	1	107.556	1.011	.330
	Within Groups	1702.889	16	106.431		
	Total	1810.444	17			

4.7. EXERCISE SESSIONS

Each group of children completed eight weeks of consecutive exercise classes conducted either in the Biokinetic Clinic at Wintec or at schools. Table 4.4. presents attendance rates for the two intervention groups.

The average attendance of the task-oriented group at the 8 classes was 7.8 classes. Out of nine participants, eight (88.9%) attended all exercise sessions, one child (11.1%) attended 6 sessions.

In strength training group, the mean number of completed sessions was 7.7. Of the nine children assigned to the strength intervention program, seven (77.8%) attended every class, one (11.1%) child missed two sessions, one (11.1%) child missed only one session.

Reasons for non-attendances were sickness (n=3) and parents' scheduling conflict that prevented them from dropping children at the Clinic/school (n=2).

Table 4.4.
Attendance of the exercise sessions

Number of attended sessions	**8**	**7**	**6**	**5**	**4**
Task-oriented group (number of children)	8	---	1	---	---
Strength training group (number of children)	7	1	1	---	---

As discussed in Chapter 3, children from both intervention groups completed the researcher-led sessions either individually or in groups of two.

Individual sessions were held with three children (33.3%) from task-oriented group participated, and four children from the strength-oriented group (44.4%; see Table 4.5).

All sessions were identical from class to class for each group. Changes were implemented only in terms of intensity and the number of repetitions and sets.

Table 4.5.
Intervention groups by the mode of delivery of supervised sessions

	Individual session	Group session
Task-oriented group, number of children; (%)	n=3 (33.3)	n=6 (66.7)
Strength-oriented group, number of children; (%)	n=4 (44.4)	n=5 (55.6)

Changes in task-oriented group included:

- During sessions 1-2, the "Circuit" exercise was performed twice; during sessions 3-8 – three times
- During sessions 5-8, the "Rolling a stick" exercise was performed using 1 kg dumbbell
- During sessions 5-8, the "Agility ladder" exercise was appended with a second round of running up and down the ladder

In the strength-training group, only one change was made starting week 5, namely, increasing the number of repetitions for each exercise in the second round from 7 to 10.

4.8. HOME EXERCISES AND LOGBOOKS

At the end of each exercise session participants were provided with a home exercise logbook with the description of exercises and smiley faces for children to indicate their level of enjoyment. The researcher demonstrated an exercise and had a child perform it under the researcher's supervision, who explained the main purposed of the exercise and corrected the technique of performing the exercise, if needed. It usually took the children 2-3 repetitions to get the exercise right.

At home, the children performed exercises during six consecutive days, excluding the day of the researcher-led exercise session. The guidelines for filling out the logbook were discussed first of all with the child with pointing out that making those records would be their responsibility, followed up by conversations with parents, who were instructed about how they could help, support and encourage their children.

The majority of the children performed all eight home exercises for at least one day (six children from the task-oriented group and five from the strength training one). The results of

the analysis of the logbook data is presented in Figures 4.3. and 4.4., for the task-oriented program and strength training program, respectively. For each exercise, the number of days indicated by children as completed was counted and calculated in percentage. If a child did not attend the supervised exercise session, he/she did not receive instructions regarding the home exercise session and their data were not taken into account in calculating the compliance rate.

The means and standard deviations were counted for each group. The result of the task-oriented group is M=81.4%; SD =8.2; for the strength training group is M= 73%; SD = 18.3.

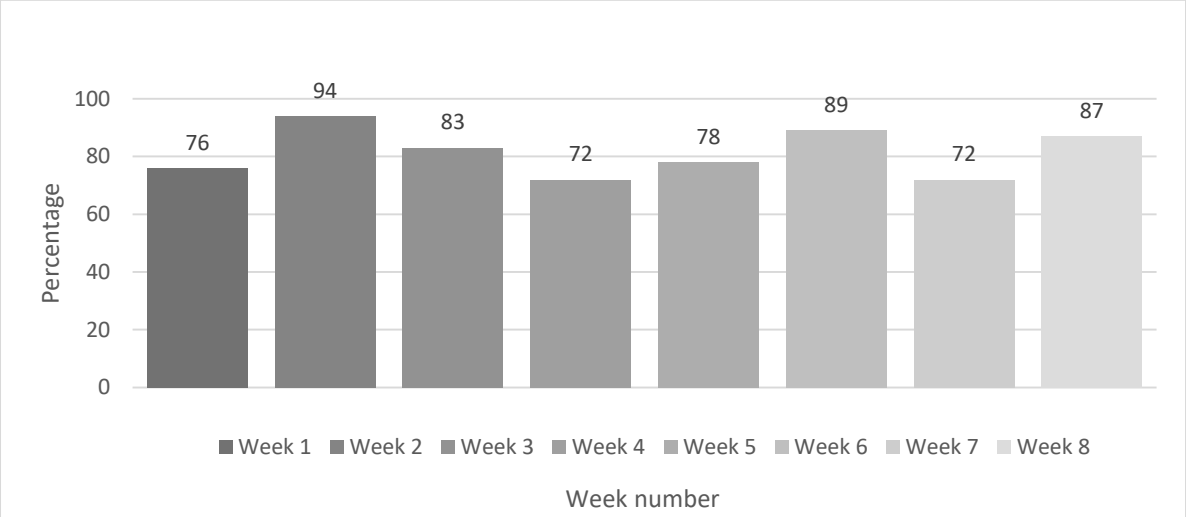

Figure 4.3.: ***Exercise compliance in percentages from week 1 to 8 in the task-oriented group***

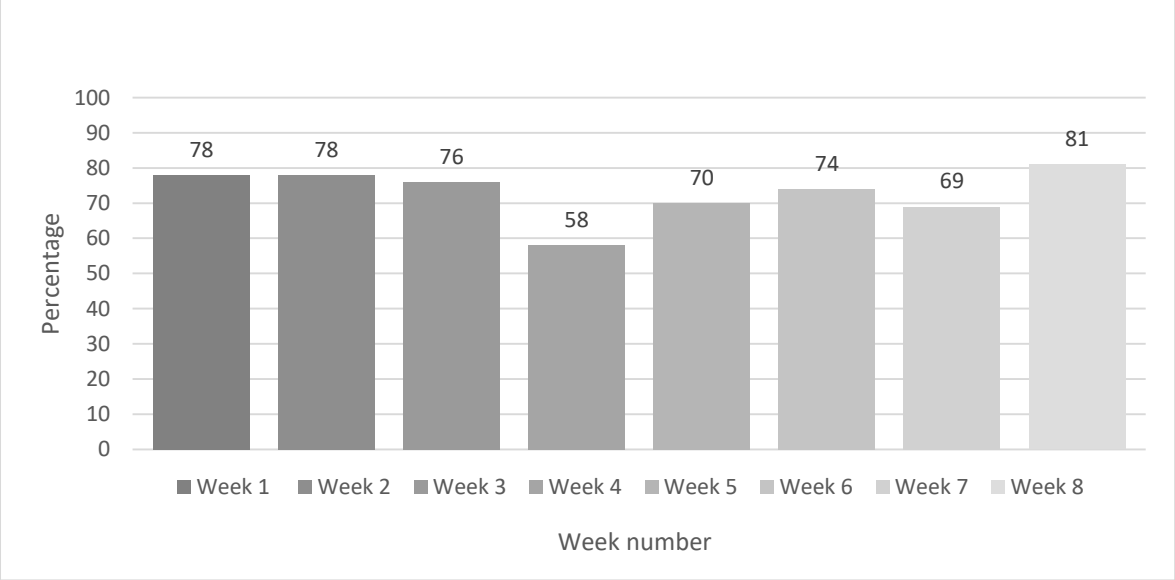

Figure 4.4.: ***Exercise compliance in percentages from week 1 to 8 in the strength training group***

The main reported reason for not completing home exercises was “Forgot” (43%). Other reasons that were mentioned as well, including “Not enough time” (27%), “Was away” (13%), “Was sick” (11%) and others (6%). Notably, among the children whose parents were involved in the program and visibly greatly concerned about their child impairment, the percentage of the “Forgot” answer was lower.

It also deserves mentioning that for exercises that demanded special equipment (e.g., elastic band, beanbag, plastic plate) the compliance rate was lower (week 4 of strength program; week 4 and 7 of the task-oriented program) if compared with exercises that did not need any equipment.

4.9. STATISTICAL ANALYSIS OF THE PRIMARY OUTCOME MEASURE (MABC-2)

After completing the intervention program, all children were tested again and the post-results for Total score as well as subtests (manual dexterity, ball skills, balance) were obtained and recorded.

In this section, the results of the Movement Assessment Battery for Children (MABC) outcome measure will be presented. Firstly, for each intervention group, the results of within-group analysis of the MABC scores taken before and after treatment will be presented. Secondly, the between-group analysis with respect to the MABC scores will be discussed.

4.9.1. Within-Group Analysis: Movement Assessment Battery for Children (MABC-2)

Within-group analysis was run to determine if the intervention program helped, that is, if it led to statistically significant differences in the children’s performance on the four measurements taken before and after the intervention. To that end, a series of paired-samples t-tests were run in the SPSS Statistics computer program.

4.9.1.1. Task-oriented group

All nine children of the task-oriented group completed the MABC-2 test before and after the 8-week intervention program. The means and standard deviations for the pre- and post-intervention probes are reported for each subtest and for total score in Table 4.6. (a,b).

As the analysis demonstrates, the task-oriented program led to statistically significant improvement of all dimensions of motor proficiency, including total score ($p<.001$), manual dexterity ($p=.004$), ball skills ($p<.001$), and balance ($p=.001$).

Table 4.6.
Within-Group Analysis of the MABC total score, manual dexterity, ball skills, and balance for the task-oriented group.

a) Paired Samples Statistics

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Total1	53.78	9	10.414	3.471
	Total2	70.33	9	12.748	4.249
Pair 2	Ball1	12.89	9	3.100	1.033
	Ball2	17.22	9	4.147	1.382
Pair 3	Balance1	23.89	9	5.754	1.918
	Balance2	29.33	9	6.285	2.095
Pair 4	MD1	17.00	9	5.123	1.708
	MD2	23.78	9	4.494	1.498

Note: **Total 1** – pre-intervention total score; **Total 2** – post-intervention total score; **Ball1** – pre-intervention aiming and catching score; **Ball2** - post-intervention aiming and catching score; **Balance1** – pre-intervention balance score; **Balance2** – post-intervention balance score; **MD1** – manual dexterity pre-testing score; **MD2** – manual dexterity post-testing score

b) Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Total1 - Total2	-16.556	5.981	1.994	-21.153	-11.958	-8.303	8	.000
Pair 2	Ball1 - Ball2	-4.333	2.179	.726	-6.009	-2.658	-5.965	8	.000
Pair 3	Balance1 - Balance2	-5.444	3.283	1.094	-7.968	-2.921	-4.975	8	.001
Pair 4	MD1 - MD2	-6.778	5.069	1.690	-10.674	-2.881	-4.011	8	.004

Note: **Total 1** – pre-intervention total score; **Total 2** – post-intervention total score; **Ball1** – pre-intervention aiming and catching score; **Ball2** - post-intervention aiming and catching score; **Balance1** – pre-intervention balance score; **Balance2** – post-intervention balance score; **MD1** – manual dexterity pre-testing score; **MD2** – manual dexterity post-testing score

4.9.1.2. Strength-training group

Only 9 children from 11 who were allocated in strength training intervention group completed 8-week exercise program and were undertaken MABC-2 test twice (pre- and post-intervention). One family moved to another town, one child failed in attendance of exercise sessions (participated only in 3 out of 8) and cancelled twice post-intervention testing session, and the researcher have made a decision not to take into account her data.

The means and standard deviations of the pre-test to post-test probes of the primary outcome measures are presented in Table 4.7.

Table 4.7.
Within-Group Analysis of the MABC total score, manual dexterity, ball skills, and balance for the strength-training group.

a) Descriptives

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Total1	48.44	9	10.370	3.457
	Total2	63.00	9	18.152	6.051
Pair 2	Ball1	13.67	9	2.500	.833
	Ball2	16.56	9	7.002	2.334
Pair 3	Balance1	17.56	9	5.681	1.894
	Balance2	24.44	9	9.501	3.167
Pair 4	MD1	17.22	9	5.911	1.970
	MD2	20.89	9	7.557	2.519

Note: **Total 1** – pre-intervention total score; **Total 2** – post-intervention total score; **Ball1** – pre-intervention aiming and catching score; **Ball2** - post-intervention aiming and catching score; **Balance1** – pre-intervention balance score; **Balance2** – post-intervention balance score; **MD1** – manual dexterity pre-testing score; **MD2** – manual dexterity post-testing score

b) Paired Samples Test

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Total1 - Total2	-14.556	8.862	2.954	-21.367	-7.744	-4.928	8	.001
Pair 2	Ball1 - Ball2	-2.889	5.732	1.911	-7.295	1.517	-1.512	8	.169
Pair 3	Balance1 - Balance2	-6.889	6.254	2.085	-11.696	-2.082	-3.305	8	.011
Pair 4	MD1 - MD2	-3.667	3.000	1.000	-5.973	-1.361	-3.667	8	.006

Note: **Total 1** – pre-intervention total score; **Total 2** – post-intervention total score; **Ball1** – pre-intervention aiming and catching score; **Ball2** - post-intervention aiming and catching score; **Balance1** – pre-intervention balance score; **Balance2** – post-intervention balance score; **MD1** – manual dexterity pre-testing score; **MD2** – manual dexterity post-testing score

As the analysis demonstrates, the strength-training program led to statistically significant improvement of the three dimensions of motor proficiency, including total score (p=.001), manual dexterity (p=.011), and balance (p=.006). The program also led to the improvement of aiming and catching skills (Ball), by increasing the group mean on the Ball subtest from 13.67 to 16.56 (see Table 4.7.a), although this change did not the conventional level of statistical significance (p=.169, see Table 4.7.b).

4.9.1. Between-Group Analysis: Movement Assessment Battery for Children (MABC-2)

A series of four one-way ANOVAs was run in order to check if the two intervention groups differed in terms of the post-intervention levels of four outcome variables (MABC subtests and total score). The results are summarized in Table 4.8.

Table 4.8.
Between-Group Analysis of MABC total score, manual dexterity, ball skills, and balance

a) Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Total2	Task group	9	70.33	12.748	4.249	60.53	80.13	42	82
	Strength group	9	63.00	18.152	6.051	49.05	76.95	28	87
	Total	18	66.67	15.677	3.695	58.87	74.46	28	87
MD2	Task group	9	23.78	4.494	1.498	20.32	27.23	16	29
	Strength group	9	20.89	7.557	2.519	15.08	26.70	6	30
	Total	18	22.33	6.212	1.464	19.24	25.42	6	30
Ball2	Task group	9	17.22	4.147	1.382	14.03	20.41	10	23
	Strength group	9	16.56	7.002	2.334	11.17	21.94	4	26
	Total	18	16.89	5.593	1.318	14.11	19.67	4	26
Balance2	Task group	9	29.33	6.285	2.095	24.50	34.16	16	36
	Strength group	9	24.44	9.501	3.167	17.14	31.75	8	36
	Total	18	26.89	8.210	1.935	22.81	30.97	8	36

b) ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Total2	Between Groups	242.000	1	242.000	.984	.336
	Within Groups	3936.000	16	246.000		
	Total	4178.000	17			
MD2	Between Groups	37.556	1	37.556	.972	.339
	Within Groups	618.444	16	38.653		
	Total	656.000	17			
Ball2	Between Groups	2.000	1	2.000	.060	.809
	Within Groups	529.778	16	33.111		
	Total	531.778	17			
Balance2	Between Groups	107.556	1	107.556	1.658	.216
	Within Groups	1038.222	16	64.889		
	Total	1145.778	17			

The group assignment did not influence the post-test results, as evidenced by the absence of statistically significant differences between the two groups in terms of the means of the outcome variables ($p>0.05$). Thus, the post-intervention performance improved regardless of the group the participants were allocated to.

4.9.3. Analysis of factors affected post-intervention MABC- 2 total score and subtests score results

Beside the between-group analysis, the more stringent test was running in order to check if the type of the program affected each of the outcome variables, if controlling for other variables that could be reasonably expected to affect the outcome variables (age, BMI, the baseline levels of the respective variable, # of instructor-led sessions, # of home sessions, and mode of delivery).

Researcher conducted a series of four multiple linear regressions, with post-testing total score (Total2), manual dexterity (MD2), aiming and catching skills (Ball2), and balance (Balance2), as an outcome/dependent variable. The following acted as independent variables

- GROUP (dummy variable: 0=Task-oriented group; 1=Strength training group)
- Age
- BMI
- Baseline level of the respective variable: total score (Total1), manual dexterity (MD1), aiming and catching skills (Ball1), and balance (Balance1)
- # of instructor-led sessions (Sessions)
- # of home sessions (Home Program)
- Mode of delivery (GroupMode (1): dummy variable: 0=independent; 2=in a group of two)

4.9.3.1. Analysis of factors affected post-intervention total MABC-2 score

As a result of the analysis (see Table 4.9.), the type of intervention program does not affect the result of the post-intervention total MABC-score. Only pre-test total score (Total1) predicted, if controlling for the other variables ($p= .000$).

Table 4.9.
Linear regression model predicting the level of post-intervention total score (Total2)

	Unstandardized Coefficients		Standardized Coefficients	
	B	Std. Error	Beta	Significance
(Constant)	19.407	29.605		.527
Group (1=Strength)	-.399	3.828	-.013	.919
Age	.190	.250	.145	.464
BMI	-.904	.767	-.201	.266
Sessions	-2.168	3.356	-.093	.533
HomeProgramm	-.035	1.823	-.003	.985
ExerciseMode (1=Group)	-6.416	4.629	-.205	.196
Total1	1.232	.210	.821	.000
F			10.366	.001
R^2			.879	
N			18	

Notes: **Group** – Dummy variable indicating the type of intervention (0=task-oriented; 1=strength-training); **Age** – Age in months; **BMI** – Body mass index; **Sessions** – Number of sessions completed under the researcher's supervision; **HomeProgramm** – Number of exercise sessions completed at home; **ExerciseMode** – dummy variable indicating the mode of delivery for supervised sessions (0=individual; 1=in a group of two); **Total1** – pre-intervention level of total MABC score.

4.9.3.2. Analysis of factors affected post-intervention manual dexterity result

According to analysis (see Table 4.10.) the type of intervention group is not affected manual dexterity (MD2). But some other factors predicted the changes of the manual dexterity, when controlling for all the other variables:

- Initial score level of the manual dexterity: the higher MD1 the higher MD2; $p<.01$)
- Age, at the level of marginal statistical significance ($p=.054$): the higher age the higher MD2 (a one-year increase in age is associated with an increase in MD2 by 0.258 points, when holding all the other variables constant)
- BMI, at the $p<.05$ level: the higher BMI the lower MD2. A one-point increase in BMI is associated with a decrease in MD2 by 0.877 points, when holding all the other variables constant

Table 4.10.
Linear regression model predicting the level of post-intervention manual dexterity score (MD2)

	Unstandardized Coefficients		Standardized Coefficients	
	B	Std. Error	Beta	Sig.
(Constant)	17.544	14.889		.266
GROUP (1=Strength)	-2.021	2.032	-.167	.343
Age	.258	.118	.494	.054
BMI	-.877	.389	-.493	.048
Sessions	-2.729	1.679	-.294	.135
HomeProgramm	.442	.984	.093	.663
ExerciseMode (1=Group)	-2.606	2.473	-.210	.317
MD1	.693	.186	.599	.004
F			5.266	.010
R^2			.787	
N			18	

Notes: **Group** – Dummy variable indicating the type of intervention (0=task-oriented; 1=strength-training); **Age** – Age in months; **BMI** – Body mass index; **Sessions** – Number of sessions completed under the researcher's supervision; **HomeProgramm** – Number of exercise sessions completed at home; **ExerciseMode** – dummy variable indicating the mode of delivery for supervised sessions (0=individual; 1=in a group of two); **MD1** – pre-intervention score of the manual dexterity.

4.9.3.3. Analysis of factors affected post-intervention aiming and catching skills result (Ball2)

In the case with aiming and catching skills, the intervention program does not affect the post-intervention performance of the ball skills (Ball 2), if controlling for the other variables (p=.007). The results are presented in the Table 4.11.

Another interesting finding that BMI has almost reached the conventional level of statistical significance (p=.056): The higher BMI is, the lower estimated Ball2 is, when holding all the other variables constant: more specifically, a one-point increase in BMI is associated with an estimated 0.900-point decrease in Ball2, when holding the other variables constant.

Table 4.11.
Linear regression model predicting the level of post-intervention aiming and catching skills (Ball2)

	Unstandardized Coefficients		Standardized Coefficients	
	B	Std. Error	Beta	Significance
(Constant)	7.184	17.636		.692
Group (1=Strength)	-.551	2.273	-.051	.813
Age	.174	.125	.371	.194
BMI	-.900	.415	-.562	.056
Sessions	-1.666	1.864	-.199	.392
HomeProgramm	.239	1.075	.056	.829
ExerciseMode (1=Group)	-.788	2.832	-.071	.786
Ball1	1.360	.401	.671	.007
F			2.830	.066
R^2			.665	
N			18	

Notes: **Group** – Dummy variable indicating the type of intervention (0=task-oriented; 1=strength-training); **Age** – Age in months; **BMI** – Body mass index; **Sessions** – Number of sessions completed under the researcher's supervision; **HomeProgramm** – Number of exercise sessions completed at home; **ExerciseMode** – dummy variable indicating the mode of delivery for supervised sessions (0=individual; 1=in a group of two); **Ball1** – pre-intervention score of the aiming and catching skills.

4.9.3.3. Analysis of factors affected post-intervention balance result (Balance2)

The analysis of the prediction of the type of the intervention program on the post-intervention balance result, when controlling other variables, reviled that only pre-test balance score affected post-intervention balance score (p= .016). The results are located in the Table 4.12.

Table 4.12.
Linear regression model predicting the level of post-intervention balance (Balance2)

	Unstandardized Coefficients		Standardized Coefficients	
	B	Std. Error	Beta	Significance
(Constant)	-2.309	26.127		.931
Group (1=Strength)	2.173	3.960	.136	.595
Age	.018	.236	.027	.939
BMI	-.048	.663	-.020	.944
Sessions	.521	3.061	.042	.868
HomeProgramm	.082	1.574	.013	.959
ExerciseMode (1=Group)	-.947	4.055	-.058	.820
Balance1	1.103	.380	.864	.016
F			2.856	.065
R^2			.667	
N			18	

Notes: **Group** – Dummy variable indicating the type of intervention (0=task-oriented; 1=strength-training); **Age** – Age in months; **BMI** – Body mass index; **Sessions** – Number of sessions completed under the researcher's supervision; **HomeProgramm** – Number of exercise sessions completed at home; **ExerciseMode** – dummy variable indicating the mode of delivery for supervised sessions (0=individual; 1=in a group of two); **Balance1** – Pre-intervention score of the balance.

4.10. EXERCISE ENJOYMENT SCALE

The enjoyment scale reflects the average enjoyment rating for each home exercises the child performed at home. Children had a range of smiley faces in their logbook that they were asked to circle at the end of the week. The values ranged from 1 to 5, with a higher score indicating greater enjoyment. The average scores for each exercise were calculated and the points were converted into percentages, with the maximum score (5) corresponding to 100%. The average levels of enjoyment for all 8 home exercises for both groups are presented in the Figures 4.5. and 4.6.

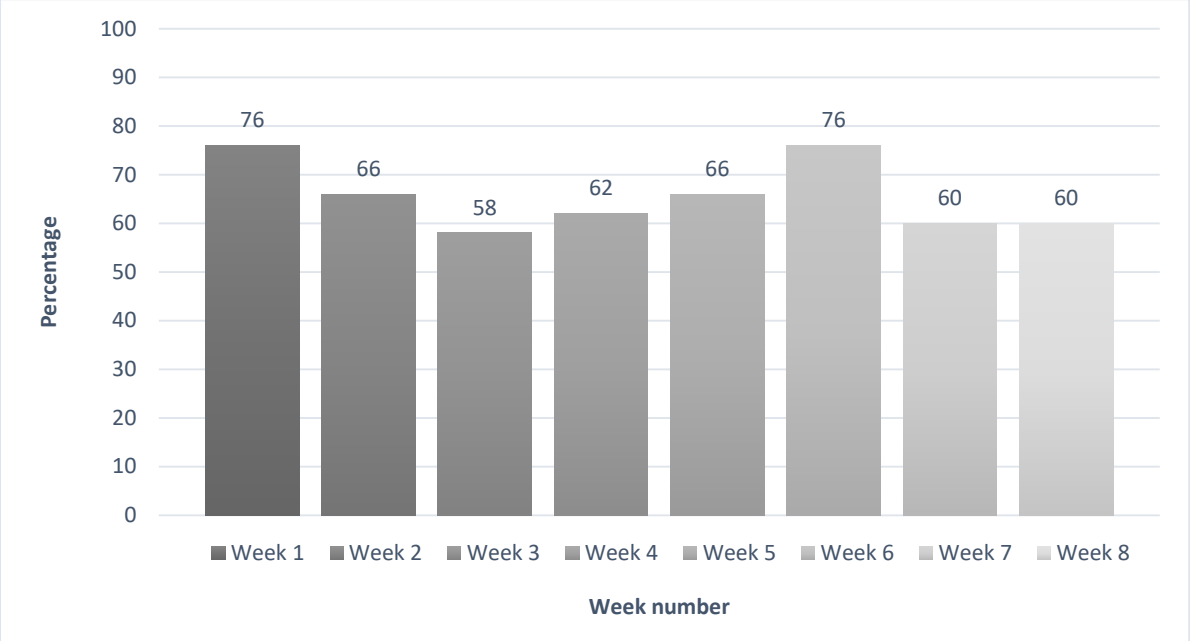

Figure 4.5. ***Weekly levels of home exercise enjoyment of the task-oriented group***

For mean level of enjoyment for the task-oriented group was M=65.5%, SD =7.07%.

For the task-oriented program the lowest levels were registered for week 3 (58%), week 4 (62%), weeks 7 and 8 (both 60%). All these home exercise were complicated and demanded more concentration and coordination than the others. For example, to perform the week 4 exercise, "Tightrope walker with beanbag on top of the head," the child had to focus on balance, correct posture and engagement of tummy muscles, as well on proper breathing. This demanded the brain to switch between its different areas and to coordinate their correct functioning.

For mean level of enjoyment for the strength-training group was M=65 %, SD=12.5%.

The lowest levels of enjoyment were registered for exercises completed in week 4 (46%), week 7 (58%) and week 8 (52%). The most favourable exercise (82%) was the one performed in week 3, called is “Bridging”.

Similarly to the pattern registered in the task-oriented group, exercises that were least enjoyed by the strength group were those that involved muscles of different parts of the body and demanded simultaneous concentration on the correct breathing techniques and controlling the posture and core muscles (i.e., “Kneeling push-ups”, “Plank”, “Sitting rowing with elastic band”), which explains why the children found them more challenging and therefore less enjoyable.

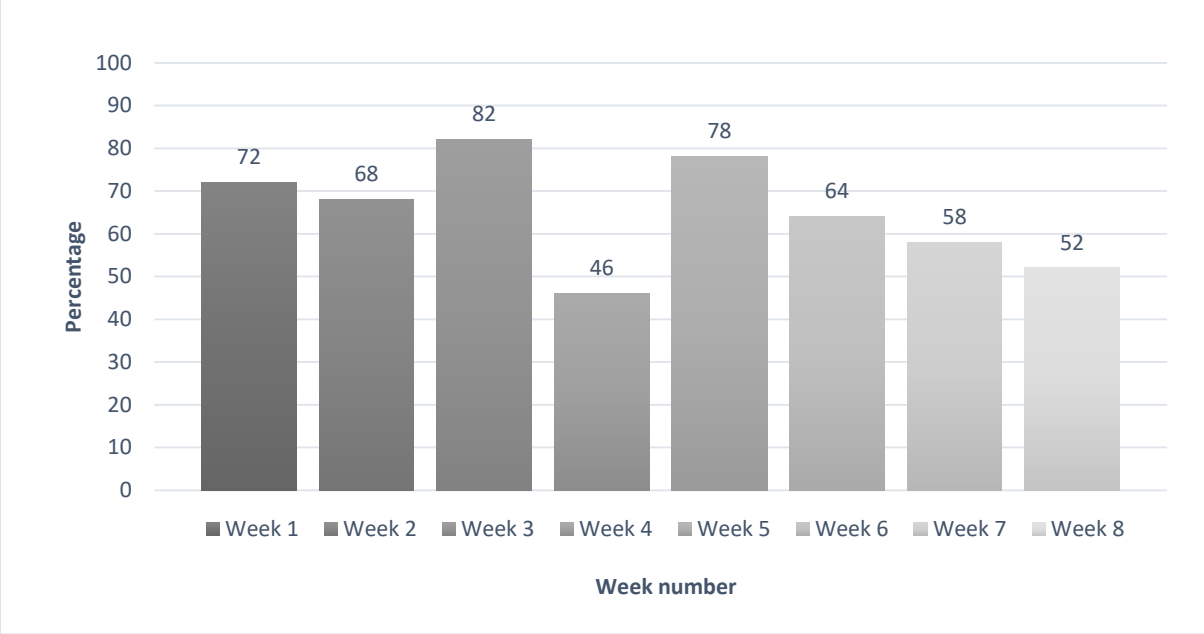

Figure 4.6. ***Weekly percentage of the home exercise enjoyment of the strength training group***

4.11. POST-INTERVENTION INTERVIEWS WITH PARENTS

Post-intervention interviews with parents were conducted via a written questionnaire. Parents filled it out either during the post-intervention testing session or at home, if they chose not to be present during the sessions conducted at schools. In the latter case, the questionnaire was sent to them with children.

Eight parents from task-oriented group (n=8) and seven from strength exercise group (n=7) filled out the questionnaire. Of those who did not complete the questionnaire, one

family from the task-oriented group were out of the city; the remaining two families from the strength training group did not contacted the Researcher, so the reason is not clear.

Parents were asked to give their own opinion of their child's enjoyment of the exercise sessions and home exercises, the necessity and form of the encouragement of children needed that.

Asked to express their level of agreement with the statement, "Overall, my child seemed to enjoy attending the exercise sessions," most parents (n=13) reported that they "strongly agreed" (n=10) or "agreed" (n=3) with the statement. Two parents were ambivalent on the question.

The questions and responses for the second and third part of the questionnaire are presented in Table 4.13.

Table 4.13.
Responses to the parent post-intervention interview questions

a) Task-oriented group

	Always	**Usually**	**Sometimes**	**Rarely**	**Never**
How much you think your child enjoyed doing the home exercises?	3	1	3	1	0
How often did your child need encouragement from you to complete home exercise?	0	1	3	3	1

b) Strength training group

	Always	**Usually**	**Sometimes**	**Rarely**	**Never**
How much you think your child enjoyed doing the home exercises?	2	5	0	0	0
How often did your child need encouragement from you to complete home exercise?	0	2	2	2	1

According to the reported results, the majority of parents (n=4 in task-oriented group; n=7 in strength exercise group) reported that their child enjoyed performing home exercises, but children needed some encouragement to complete them (n=7 in task-oriented and n=6 in strength exercise group). Only two parents, one per group, responded that their child never needed encouragement.

The types of encouragement that parents mentioned more often (as provided "usually", "often", "sometimes") were "Offering a positive feedback during and/or after the exercise session," "Simple reminder about the need to compete the exercises," and "Explaining the benefits of exercises." Among "Rarely" and "Never," the most popular responses were "Offering rewards" and "Leading by example by completing exercises together." This trend is traceable in the responses of the parents of both groups.

4.12. STATISTICAL ANALYSIS OF THE COMPLIANCE TO TREATMENT

To answer RQ3, a series of three one-way ANOVAs was run to compare the intervention groups in terms of compliance to treatment among the children, by contrasting the group means on three variables: attendance of the researcher-led sessions, the number of completed home exercise sessions, and the levels of enjoyment and encouragement needed.

4.12.1. Attendance of the research-led exercise sessions

According to analysis, there are no statistically significant differences (p=.736) between the two groups in terms of how many researcher-led sessions children attended (Table 4.14.).

Table 4.14.
Between-group analysis of the research-led exercise sessions attendance

a) Descriptives

Sessions

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Task oriented group	9	7.78	.667	.222	7.27	8.29	6	8
Strength training group	9	7.67	.707	.236	7.12	8.21	6	8
Total	18	7.72	.669	.158	7.39	8.05	6	8

b) ANOVA

Sessions

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.056	1	.056	.118	.736
Within Groups	7.556	16	.472		
Total	7.611	17			

4.12.2. Between-group analysis of the sessions completed at home

The between-group analysis was run in order to check if there are statistically significant differences between the two groups in terms of how many sessions children completed at home, without the researcher's supervision.

A one-way ANOVA has not revealed statistically significant differences (p=.382) between the groups (Table 4.15).

Table 4.15.
Between-group analysis of the sessions completed at home

a) Descriptives

HomeProgramm

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Task-oriented group	9	7.33	1.118	.373	6.47	8.19	5	8
Strength training group	9	6.78	1.481	.494	5.64	7.92	5	8
Total	18	7.06	1.305	.308	6.41	7.70	5	8

b) ANOVA

HomeProgramm

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.389	1	1.389	.806	.382
Within Groups	27.556	16	1.722		
Total	28.944	17			

4.12.3. Between-group analysis of enjoyment and level of encouragement needed to complete home exercises

The level of enjoyment and level of encouragement children needed to complete home exercises was assessed before. The statistical between-group analysis revealed no statistically significant differences (p>.05) for both enjoyment and encouragement between the two groups (see Table 4.16.)

Table 4.16.
The between-group analysis of enjoyment and level of encouragement needed to complete home exercises

a) Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean Lower Bound	95% Confidence Interval for Mean Upper Bound	Minimum	Maximum
Enjoyment	Task	8	3.7500	1.16496	.41188	2.7761	4.7239	2.00	5.00
	Strength	7	4.2857	.48795	.18443	3.8344	4.7370	4.00	5.00
	Total	15	4.0000	.92582	.23905	3.4873	4.5127	2.00	5.00
Encouragement	Task	8	2.50	.926	.327	1.73	3.27	1	4
	Strength	7	2.71	1.113	.421	1.69	3.74	1	4
	Total	15	2.60	.986	.254	2.05	3.15	1	4

b) ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Enjoyment	Between Groups	1.071	1	1.071	1.275	.279
	Within Groups	10.929	13	.841		
	Total	12.000	14			
Encouragement	Between Groups	.171	1	.171	.166	.690
	Within Groups	13.429	13	1.033		
	Total	13.600	14			

Chapter 5: Discussion

5.1. INTRODUCTION

The study sought to compare the effect of the task-oriented and strength training exercise intervention programs on improving the motor skills of children with developmental coordination disorder (DCD) as well as the level of their compliance to treatment. To the researcher's knowledge, this was the first study to have addressed these questions. The long-term implications of the research project include finding the best approach to rehabilitating children with DCD that could be implemented in the holistic manner by healthcare professionals.

All research questions were explored and the outcomes are discussed in this chapter. The results of the study indicate that both exercise intervention programs have a positive, statistically significant effect on the motor proficiency. The levels of compliance to and enjoyment of the exercise program have been found to be sufficiently high in both programs, with no statistically significant differences between the programs.

5.2. BASELINE VARIABLES OF THE STUDY POPULATION

The following variables were measured and statistically analysed in terms of their effect on the treatment outcome: age, BMI, MABC-2 pre-intervention scores (including total test score, manual dexterity, ball skills, and balance), and DCDQ- 07 score. The two groups were found to be statistically indistinguishable in terms of all variables, but balance, indicating that the randomization was successful.

The female-male rate was 2:1, which reflects the gender distribution of DCD globally, according to the Diagnostic and Statistical Manual (2013), which states the DCD is prevails among boys over girls by the factor ranging from 2 to 3.

In terms of BMI measurements, the results depart from the previously reported observations that suggested high (26%-37%) prevalence of DCD among obese and overweight children (Schott et al., 2007; Layte & McCrory, 2011; Morton, 2015). In the present study, the majority of participants had either normal weight (38.8%) or low weight (55.5%). Only one child (5.5%) was overweight, as determined by the NHS National Obesity Observatory

guidelines on BMI percentiles (2011). However, these studies were conducted in Germany and Ireland; not in New Zealand with her cultural diversity, which could have affected the results. Given the absence of systematically collected data on the fitness level of children with DCD in New Zealand, the researcher doesn't find it valid to make any cross-national comparisons or generalize the data from this small, highly selective sample to the national population and views such an analysis as a promising avenue for future research.

As for the baseline levels of the motor skills as measured with MABC, they were low, with the mean total score percentile 6.4 for the task-oriented group and 5.3 for the strength training group, which corresponds to the "probable movement difficulty", with the score falling between the 5^{th} and 15^{th} percentiles (MABC-2 Examiner's Manual, 2007)

5.3. CHANGES IN MOVEMENT ASSESSMENT BATTERY FOR CHILDREN (MABC-2) SCORE IN EACH INTERVENTION GROUP

Both intervention groups demonstrated statistically significant improvements in MABC scores after an 8-week intervention program, as measured by the total score and all subtests in task-oriented group, and the total score and all the subtests, but ball ($p=.169$), in the strength training group.

If compared with existing researches, these outcomes are either comparable with or more pronounced than the results reported in previous research. For example, Ferguson et al. (2015) after nine weeks of a task-oriented program (sessions were twice a week) found positive changes with high statistical significance for the total score ($p< 0.01$), manual dexterity ($p< 0.01$), and balance ($p< 0.01$). Echoing the results of the present research, the Ball skills demonstrated no statistically significant improvement ($p<0.08$). 9-10 year-old children participated in the program, and they did not have specific exercises, but practiced skills in outdoor games, by using balls, sticks, planks, and baskets.

In a related study, Hung & Pang (2010) after a 10-week exercise intervention program discovered positive differences in total score, but not in any of the subtests. The study involved 6-10-year-olds, who underwent a 10-week intervention programme that consisted of one weekly session. The intervention included agility and balance, bilateral coordination exercises, aiming and catching, and core stability exercises.

Peens et al. (2008) demonstrated significant improvements in total MABC score and in all the subtests (besides manual dexterity, $p=.21$) after finishing an 8-week (twice a week)

intervention programme. The exercise rehabilitation programme was very similar to the one used in the present study, except for the fine motor skills exercises, which included special exercises that mostly engaged finger muscles, e.g., by having a child draw a circle path on paper and walk with their left and right thumbs; pinch washing pins on elephant's head; or cut out pictures with a scissor. In contrast, the present study included exercises that engaged both finger muscles and wrist muscles (e.g., rolling the stick without/with a 1-kg weight, crumpling a piece of paper into a ball).

This indicates that the exercise rehabilitation program employed in the present may be more effective in improving the performance of the majority of motor skills, suggesting that the same strategy should be employed in future DCD interventions.

The effect of the strength exercise program on improving motor proficiency cannot be directly compared with other studies, as they either used different assessment tools or included only core-strength exercises (Kane and Bell, 2009; Au et al., 2014). Even so, those studies reported mixed results. Whereas they did report improving motor skills with statistical significant results, only one study applied the MABC-2 assessment tool and assessed changes in balance skills as a result of the strength exercise program (Kordi et al., 2016). Whereas the program did improve the static balance performance ($p < .05$), it failed to produce statistically significant improvement on dynamic balance performance ($p > .05$).

5.4. BETWEEN-GROUP ANALYSIS OF THE EFFECTIVENESS OF THE PROGRAMS IN TERMS OF PRIMARY OUTCOMES (MABC-2)

The analysis found no statistically significant differences ($p > .05$) between the two intervention groups in terms of the post-intervention levels the four outcome variables: total score, manual dexterity, aiming and catching, and balance. Therefore, the two programs were equally effective in generating the post-intervention levels of performance.

This is consistent with the results of a recent study that compared task-oriented and core training programs to find that the core stability exercise program to be "as effective as task-oriented training in improving motor proficiency among children with DCD" (Au et al., 2014). In the current study, the core stability exercises were a part of the strength training program.

In sum, both exercise intervention programs can be expected to produce comparable and promising results in terms of improving motor performance among children with DCD.

5.5. EXERCISE ENJOYMENT AND COMPLIANCE TO TREATMENT STOPPED HERE

The 8-week exercise intervention program appears to have been well accepted by participants. The mean attendance in the task-oriented group was 7.8 classes (97.5%), in the strength-training group – 7.7. classes (96.3%). All children enrolled in the task-oriented group completed the intervention program; nine children out of enrolled 11 finished the intervention program (one child had dropped before classes started; one child completed only three sessions and dropped without explanations). No injury or emotional distress were registered during the classes. Reasons for non-attendances were reasonable and not related to the intervention program (sickness, parents unable to drop a child).

Overall, the attendance was higher than reported in previous studies. For instance, Peters and Wright (1999) achieved the mean attendance of their exercise classes of 86%; Morton (2015) found the mean attendance rate to be 85%. Au et al. (2015) in their research project had the attendance rate of the core stability group to be 6.2 ± 1.2 sessions, for the task-oriented group 6.8 ± 1.0 sessions. These studies tested 10-week intervention programs (8 classes in Au et al. project) twice a week, so it is plausible to expect that the attendance in the present study could have dropped if the program had lasted longer, due to the difficulty for the families to accommodate the treatment into their other schedules.

The comparative analysis of compliance to the treatment between the two group showed no statistically significant differences ($p > .05$) between the two groups in terms of how many researcher-led sessions children attended, and how many sessions were competed at home. This result is similar to the findings reported by Au and colleagues (2014), who also found no differences between the core stability and task-oriented groups ($p = 0.333$).

Finally, the analysis of the levels of enjoyment and parental encouragement needed between two intervention groups found no statistically significant differences ($p > .05$) between the two groups. The mean level of the enjoyment for the task-oriented and strength training groups had comparable rates: 65.5 ± 7.07% and 65 ± 12.5%, respectively. Interestingly, the lowest enjoyment levels both groups were registered for complex exercises that demanded completing multi-component tasks, such as posture, balance, breathing control, and coordination of different muscle groups. This pattern should be taken into consideration when designing exercise rehabilitation programs for children with DCD in order to maintain high adherence rates and consistency in performing rehabilitation programs.

Another point that is worthy of separate discussion is logbook completion, which functions as an instrument to assess the compliance to, and enjoyment of, home-based exercise sessions. The key limitation is that the process of filling out the logbook cannot be standardised. Some children had issues with completing logbooks even after detailed explanations, others performed exercises, but forgot to fill the logbook out or to bring it back to the researcher. In discussions with children, it was repeatedly emphasized that filling out the logbook was children's responsibility, a tactic intended to rise their confidence and self-esteem. Yet, even despite apparently trying their best, the children still needed some encouragement and supervision from their parents. This emphasizes the importance of parents' involvement. To maximize the outcome of the treatment, parents should not be disengaged, but work as part of the "child-healthcare professional-parent" team. This idea resonates with an observation made by Morton (2015), who noted that "truthful and accurate completion of a log book depends on the involvement on the parents as well as the children."

5.6. STUDY STRENGTHS

To the author's knowledge, no study has previously compared the task-oriented and strength training intervention programs in terms of motor proficiency improvement and level of enjoyment in children with DCD.

The key strengths of this study include its design and methodological rigor. The study was a randomised control experiment, with the efficiency of randomization confirmed by statistical between-group analyses. Standardized, previously validated assessment tools (i.e., Movement Assessment Battery for Children, Developmental Coordination Questionnaire-2007) were used to recruit and test participants, which ensured the accuracy and reliability of the data collection and made it possible to compare the outcome of this study with the results obtained in previous research.

All assessments and exercise sessions were conducted by the same researcher, which served to minimize the effect of unaccounted factors. So did the sufficiently high, comparable attendance rates in both groups.

5.7. STUDY LIMITATIONS

Its strengths notwithstanding, this study suffered from several limitations that need to be addressed in future research.

First, the number of children participated in the project was 18. Although, as reflected in the results of the within-group analysis and review of the previous research, this sample size was both comparable with those used in other studies and big enough to register the improved motor proficiency of the participants at the conventional levels of statistical significance, it does not rule out the possibility that the absence of between-group differences could better be explained with the small sample size, rather than the similarity of the programs in generating statistically indistinguishable outcomes. In other words, it seems plausible to suggest that the two programs could actually differ in their effect on the particular motor proficiency dimensions, but the size of the sample left the study underpowered to register those differences at the statistically significant level. Given the pilot nature of this study, the researcher looks forward to the explore this possibility in future research, by increasing the sample size.

Second, again, given the pilot character of this study, the geographic area from which the participants were recruited was limited to the city of Hamilton. Therefore, the results cannot be generalised to the larger population, especially given the high diversity of population in New Zealand in terms of cultural and socio-economical backgrounds. To overcome this limitation, future research should expand the sample to include a larger, nationally representative sample of children, and account for the differences in their backgrounds by including them as control variables in statistical analyses.

Finally, the limited timeframe of this project, with post-treatment measurements taken immediately after the completion of the program, prevents us from assessing the stability of achieved improvements over time. Given that this study did not seek the explore the long-term consequences of the interventions, this does not present a direct limitation of this study. However, it no doubt presents a promising and important avenue of exploration and should be addressed in future projects.

5.8. RECOMMENDATIONS

The results of the study led the researcher to proposing a number of recommendations that can used in designing and implementing rehabilitation programs for children with DCD. These recommendations include the following:

- In designing rehabilitation programs, exercises from both tested intervention programs should be included, to ensure comprehensive treatment by not only engaging core muscles, but strengthening upper- and lower-body muscles as well.

- Home exercises should be an integral part of rehabilitation programs, with parents providing encouragement to children and working closely with healthcare professionals to ensure consistency and high adherence rates.

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https://www.random.org/

Appendices

Appendix 1: Letter of Ethical Approval

Waikato Institute of Technology
Research and Postgraduate Office
D Block, Tristram Street / Private Bag 3036
Hamilton 3240
e-mail research@wintec.ac.nz
Telephone 07 834 8800 Extn 3582

27th July 2017

Alena Adaikina
Centre for Sport Science and Human Performance

Dear Alena

HUMAN ETHICS RESEARCH APPLICATION

Title: Comparing the effect of task-oriented intervention programme vs. strength training programme in improving motor proficiency in children aged 8-12 years with DCD

Thank you for you application which was considered by the Human Ethics in Research Group on 20th July 2017. It is with pleasure I advise ethics approval for your project is granted conditional on adding the standard CSSHP pre-exercise screening questionnaire the participant information documentation.

Ethical approval is granted until 31st December 2017 or until the project has been completed, whichever comes first.

Please note that should there be any changes to the approved research project then it will need to be referred back to the committee for further consideration.

The Human Ethics in Research Group wishes you every success with this project.

Kind regards

Gaby Douglas
pp Elizabeth Bang
Chairperson
Wintec Human Ethics in Research Group

Cc Glynis Longhurst

Appendix 2: Information leaflet for parents

Information leaflet for parents/caregivers

Invitation to a research study

The title of this study is "Comparing the Effect of Task-Oriented Intervention Program vs. Strength Training in Improving Motor Proficiency in Children Aged 8-12 Years with Developmental Coordination Disorder (DCD): A Randomized Controlled Pilot Study". The research is being carried out by Alena Adaikina, an accredited exercise physiologist in the Centre of Sports and Exercise Science at Waikato Institute of Technology.

The study is a part of the Master's program.

What is this research about and why is it being done?

The number of children with movement difficulties, or developmental coordination disorder (DCD), is estimated to be about 5-6% of school-age population. These children have movement difficulties that can affect their daily activity life, as well as their learning process, confidence, sport participation and socialization.

The are two exercise program that have been found by previous research to demonstrate good results in terms of improving balance and coordination, ball skills and manual dexterity. This research intends to compare the two to identify the most effective and children-friendly exercise rehabilitation program for 8-12 years old children with DCD.

Who could be object for the study?

Children with the next symptoms could be an object of the research:

- Clumsiness
- Balance and coordination problem
- Slowness and inaccuracy of motor skills performance (e.g., when catching an object, using scissors or cutlery, handwriting, riding a bike, or participating in sports)
- Learning difficulties
- Daily activity life difficulty (dressing, eating, personal hygiene, spatial orientation)

If your child displays two or more symptoms, including motor skills performance difficulties, (s)he could possibly take part in the research study.

What will happen if you decide to participate in this study?

The study will be explained to you and your child in details and you will be asked to sign a consent form on behalf of your child, if you choose to participate. You and your child will be invited for the first appointment, when your child will be seen by a clinical exercise physiologist. The appointment will take about an hour. You will be asked to fill a questionnaire about your child's skills. Your child's balance, ball skills and manual dexterity will be also be assessed during the first appointment.

The recruitment process will take approximately 1-1.5 month. The exercise rehabilitation program will be performed in group sessions, meaning you may have to wait until the necessary number of children have been recruited. Once all participants have completed the initial assessment, they will be randomly assigned into two different exercise groups, both of which have been found by previous studies to be effective in treating DCD.

Exercises will be held once a week for 45 minutes at the Wintec Biokinetic Clinic, for 8 weeks. All classes will be run by the Researcher, and will involve exercises to improve balance, strength, agility, and coordination. Children will be encouraged to interact with children of the same age and the same level of motor skills development during exercise sessions.

In addition, each child will be asked to perform exercises at their convenience at home, which they will be encouraged to perform at home during the week. To keep record, you will be provided with a logbook to indicate how many exercises you child did and to evaluate the level of your child's enjoyment.

At the end of 8 weeks, your child will be reassessed individually by the same specialist.

Data

Your child's scores will be used at the end of the study to evaluate which program is more beneficial in terms of improving the participants' manual dexterity, ball skills, and balance. All data will be coded and kept confidential, the name of your child or any other identifiable information will not be published or will not be referred to elsewhere.

Benefits

Your child will benefit from participation in the study regardless of which exercise program, strength-oriented or task-oriented, (s)he has been assigned to, as both of them have been recognized in previous research studies as useful for children with developmental coordination disorder.

Risks

As your child is taking part in physical activity, there is a small risk of injury to your child during exercise sessions. The Researcher has a First Aid Certificate.

It is possible that your child may experience some fillings of frustration or be upset during some exercises that (s)he may find challenging. The Researcher running the classes will provide support and encouragement to your child during any activities that (s)he could find difficult when in class.

Withdrawal

You are free to change your mind and withdraw from taking part in the research project at any time should you wish to do so. Participation in this study is voluntary and you will not be penalised in case of withdrawal your child.

Outcome

You will be given detailed feedback on your child's results and recommendations for the future in writing and in person by the Researcher.

Contact details

Thank you for taking the time to consider participation in this research.
If you choose to participate or have any questions about the study, please phone or text me at 022-625-65-11 or contact me by email at alena.adaikina@gmail.com.

Alena Adaikina
Accredited Exercise Physiologist (SESNZ)/Master's Student
Centre for Sport Science and Human Performance
Waikato Institute of Technology/Wintec Biokinetic Clinic
alena.adaikina@gmail.com
022-625-65-11

Appendix 3: Information leaflet for children

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Information leaflet for children

We are invited to take part in a study!

Who I am

My name is Lena, I am a clinical exercise physiologist at the Wintec Biokinetic Clinic. I use exercises to help people be healthier and stronger.

What is this study about?

This study will help us understand the impact that physical exercises, could have on improving your strength, balance, ball skills. In other words, I am trying to find the best exercise program for children of your age, that will be more beneficial for you and that you would enjoy more than others.

Why am I asking you to participate in my study?

I am looking for children age 9-11 who need help with their balance, strength, coordination and sports participation. You are being invited to take part in this study, as you are of the right age and I believe that exercise sessions will help you become more active and mobile.

You and your parent(s) will be asked to come to our clinic to answer some questions about you. After this, we do some activities to help assess your catching and throwing, balance, and drawing. We will do this to find which of these things you can do best and which need some improvement. Once we are done with this stage, you will come one day a week to do various physical exercises with me and other kids your age. Some of them will include jumping, balance exercises, some - push-ups and crunches. We will have about 2 months of weekly exercise sessions.

In addition, I will ask you to do some exercises at home daily and to evaluate how much you liked them. After we finish exercise sessions, we will do the same tests together again to see if your skills have been improved.

What if you do not like it?

I hope you have lots of fun doing exercises, but if you do not like something about them you are welcome to let your parent(s) or me know so we can how we can change them. And if you really do not like them, you can stop participating in the study at any time.

Appendix 4: Consent form

Consent Form

Project Title

Comparing the Effect of Task-Oriented Intervention Program vs. Strength Training Program in Improving Motor Proficiency in Children Aged 8-12 Years with Developmental Coordination Disorder (DCD)

Participant Consent Form

(one copy to be retained by the Research Participant and one copy to be retained by Researcher)

I…… the parent/guardian of …….. (participant's name) consent to my child being a participant in the above named research project, and I attest to the following:

1. I have been fully informed of the purpose and aims of this project
2. I understand the nature of my child's participation
3. I understand the benefits that may be derived from this project.
4. I understand that I may review my contributions at any time without penalty.
5. I understand that I and my child will be treated respectfully, fairly and honestly by the researcher/s, and I agree to treat the other participants in the same way.
6. I understand that I will be offered the opportunity to debrief during, or at the conclusion of this project.
7. I have been informed of any potential harmful consequences that may occur by my child by taking part in this project.
8. I understand that my child may withdraw from the project at any time (without any penalties)
9. I understand that my child's anonymity and privacy are guaranteed, except where I consent to waive them.
10. I understand that information gathered from me will be treated with confidentiality, except where I consent to waive that confidentiality.
11. I agree to maintain the anonymity and privacy of other participants, and the confidentiality of the information they contribute.

Parent/Guardian……Date……

Principal Researcher……..Date…….

Appendix 5: Information leaflet for health professionals and teachers

Information leaflet for Health Professionals and Teachers

Project Title

Comparing the Effect of Task-Oriented Intervention Program vs. Strength Training in Improving Motor Proficiency in Children Aged 8-12 Years with Developmental Coordination Disorder (DCD): A Randomized Controlled Pilot Study.

The project has been approved by the Human Ethics in Research Group of Wintec.

Aims

The study aims to compare the effect of task-oriented intervention program and strength training program in terms of improving motor proficiency in children aged 8-12 years with developmental coordination disorder (DCD), as defined by the Movement Assessment Battery for Children (MABC-2) and Developmental Coordination Disorder Questionnaire (DCDQ-07).

Methodology

- *Participants*

The parents of children ages 8-12 who have a movement difficulty and who meet the inclusion criteria will be asked to consent to their child's participation in this study.

- *Inclusion criteria*

Male and female children ages 8 - 12 yrs with a movement difficulty as indicated by the Movement Assessment Battery for Children (MABC-2). Children scoring a total score at the 15th percentile or below can be included in the study. The Developmental Coordination Disorder Questionnaire (DCDQ-07) will be used as an additional screening tool, with children with total score of 15-57 to be considered eligible to participate in the study.

- *Exclusion criteria*

Children with mental retardation, physical disability, that may be the cause of movement difficulty. Children with any congenital cardio-respiratory condition, congenital musculoskeletal condition, with visual and hearing disability. Children with behavioural difficulties preventing them to participate in group therapy.

- *Intervention*

Children will be placed in two groups to complete either the task-training exercise program or the strength-training one. The intervention program will last 8 weeks and will consist of eight

45-minutes weekly sessions to be held at the Wintec Biokinetic Clinic, and home program of daily exercises.
The task-oriented training group will complete balance, agility, proprioception, ball catching, and ball aiming exercises.
The strength training group will complete core, upper- and lower-body strengthening exercises.

Prescreening sampling

Children with the next symptoms could be object for the research

- Clumsiness
- Balance and coordination problem
- Slowness and inaccuracy of motor skills performance (e.g., when catching an object, using scissors or cutlery, handwriting, riding a bike, or participating in sports)
- Learning difficulties
- Daily activity life difficulty (dressing, eating, personal hygiene, spatial orientation)

If you know children displaying two or more of these symptoms, including motor skills performance difficulties, please let them know about this study and pass along informational leaflets to their parents/caregivers.

Thank you.

Alena Adaikina
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Centre for Sport Science and Human Performance
Waikato Institute of Technology
alena.adaikina@gmail.com
022-625-65-11

Appendix 6: Post-intervention parent interview

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Post-intervention parent interview questionnaire

Group: ☐ Strength-training ☐ Task-training
Child's name_____
Parent's name_____

Exercise sessions:					
How much do you agree with the following statements:	**Strongly agree**	**Agree**	**Neither agree nor disagree**	**Disagree**	**Strongly disagree**
Overall, my child seemed to enjoy attending the exercise sessions					
My child found the exercise session instructions easy to follow					
Exercise sessions provided an appropriate amount of challenge for my child					
How often did your child need encouragement from you when attending the exercise sessions?	**Always**	**Usually**	**Sometimes**	**Rarely**	**Never**
Home exercises:					
How much you think your child enjoyed doing the home exercises? [SEE ABOVE]					
How often did your child need encouragement from you to complete home exercise?					
Encouragement					
What kind encouragement, if any, did you use to motivate your child to keep doing the program:	**Always**	**Usually**	**Sometimes**	**Rarely**	**Never**
simple reminder about the need to compete the exercises					
offering rewards (candy, game time)					
explaining the benefits of exercises					
offering positive feedback during and/or after the exercise session					
leading by example by completing exercises together					
other (specify):					

Other comments:

Assessment Form

Child's name _____ **DOB**_____

Age of recruitment:_____years_____months

Parent's name:_____

Parent's phone:_____

Parent's email address:_____

Initial Assessment:_____ **Review Assessment:**_____

Height (cm)				**Height (cm)**			
Weight (kg)				**Weight (kg)**			
BMI (kg/m^2)				**BMI (kg/m^2)**			
DCDQ-07 completed				**Home exercise enjoyment scale completed**			
				Post-intervention interview with parents completed			
	Raw Score	**Stan dard Score**	**Percentile**		**Raw Score**	**Stan dard Score**	**Percentile**
ABC Total				**ABC Total**			
ABC Manual dexterity				**ABC Manual dexterity**			
ABC Aiming and Catching				**ABC Aiming and Catching**			
ABC Balance				**ABC Balance**			

Appendix 8: Task-oriented exercise program

1. “Circuit” training with stations (2-3 sets)
    - Running in and out hula hoop (6 hula-hoops)
    - Hopping on one leg at agility ladder (5 times on each leg)
    - “In and out” at agility ladder
    - Jumping with two feet together on steps (1 level → 2 level → 1 level → 3 level)
    - Running around 10 cones “Snake”
    - High knee stepping over hurdles (15 cm high) – 5 hurdles
    - Toe walking on gymnastic mats (2)
    - Zig-zag running toughing cones (6 cones)
    - Rolling stick with a rope (add 1 kg dumbbell)
    - Bear walking
    - Duck walking
    - Crab walking
2. Hockey skills with a tennis ball around cones in figure of 10 cones – 3 times
3. Catching a tennis ball with one or two hands (depending on age group) – 20 balls overall
4. Aiming cones with a tennis ball (1.5-2 m far from a chid) – 5 cones
5. Marching on unstable surface during 3 mins with 1 mins on each: soft pad, mini trampoline, dura disk.
6. Run and stop immediately by signal, then run back – 5-10 times
7. Crumpling a piece of paper (A4) into a ball, standing on one leg and throwing in a box ball then (which is 1-1.5 m far from child)

Appendix 9: Strength exercise program

1. Upper-body exercises:
    - Biceps curls with green elastic band
    - Overhead triceps extension with green elastic band
    - Pull apart with green elastic band

2. Lower- body exercises:
    - Lateral steps with green elastic band
    - Seated unilateral knee extension with green elastic band

3. Core & back:
    - Cat and Camel
    - Rocking on the back with knee to the chest
    - Bridging
    - Sit-ups
    - Bird dog
    - Kneeling plank

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Home program - Task training group
Week 1
Child's name_____

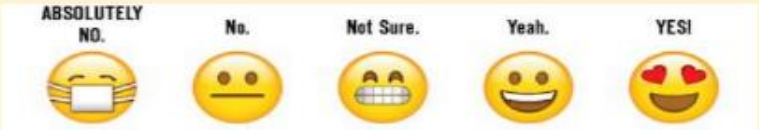
Exercise: Hopping on one leg

Description

- Stand on your good leg and try to hop up and down the room as many times as you can.
- Try it on your other leg too!

Day	Completed (Tick)	Not Completed (Tick)	How many repetitions/sets did you do? Other comments?
Day 1	☐	☐	
Day 2	☐	☐	
Day 3	☐	☐	
Day 4	☐	☐	
Day 5	☐	☐	
Day 6	☐	☐	

We'd like to know how much you enjoyed doing the exercises. Please circle the smiley that fits!



Home program - Task training group
Week 2
Child's name_____

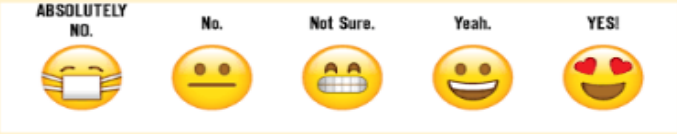
Exercise: Airplane pose

Description:

- Imagine that you are an airplane gliding through the sky.
- Flex your foot so that your toes are pointing at the ground.
- Elongate your neck and straighten your spine so that a straight line runs from your head to your foot. Try to keep your hips are parallel to the ground.
- Count how many seconds you can keep this pose (separate for the left and right leg)

Day	Completed (Tick)	Not Completed (Tick)	How many repetitions/sets did you do? Other comments?
Day 1	☐	☐	
Day 2	☐	☐	
Day 3	☐	☐	
Day 4	☐	☐	
Day 5	☐	☐	
Day 6	☐	☐	

We'd like to know how much you enjoyed doing the exercises. Please circle the smiley that fits!

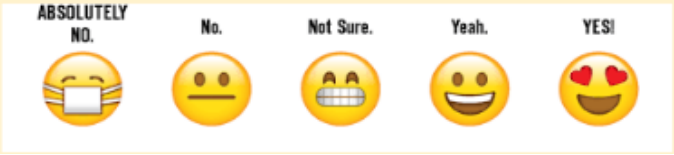


Home program - Task training group
Week 3
Child's name_____
Exercise: Throw a tennis ball into the wall
Description:

- Stay 1.5 m from the wall
- Throw a tennis ball into the wall with one arm 10 times and catch the ball with two/one arm. Throw a tennis ball with the left arm, then with the right one. Count how many times you could catch the ball and enter into the table
- If you are willing you can repeat this circuit

Day	Completed (Tick)	Not Completed (Tick)	How many repetitions/sets did you do? Other comments?	
Day 1	☐	☐	R	L
Day 2	☐	☐	R	L
Day 3	☐	☐	R	L
Day 4	☐	☐	R	L
Day 5	☐	☐	R	L
Day 6	☐	☐	R	L

We'd like to know how much you enjoyed doing the exercises. Please circle the smiley that fits!



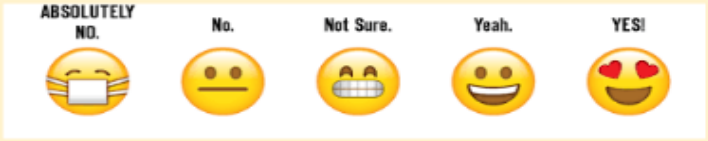
Home program - Task training group
Week 4
Child's name_____
Exercise: Tightrope Walker

Description:

- Walk heel-to-toe along the (rope) line while balancing the beanbag on your head.
- Tighten your tummy musculus. Keep your back straight.
- Count how many steps you can do with beanbag staying on your head and put the number in the table. If you have done more than 20 steps you can stop performing exercises

Day	Completed (Tick)	Not Completed (Tick)	How many repetitions/sets did you do? Other comments?
Day 1	☐	☐	
Day 2	☐	☐	
Day 3	☐	☐	
Day 4	☐	☐	
Day 5	☐	☐	
Day 6	☐	☐	

We'd like to know how much you enjoyed doing the exercises. Please circle the smiley that fits!



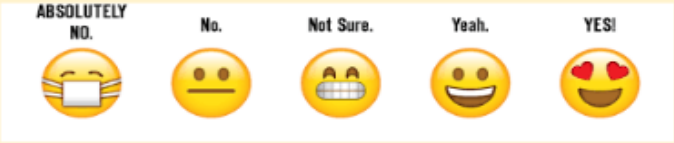
Home program - Task training group
Week 5
Child's name_____
Exercise: Throwing a tennis ball into a basket

Description:

- Stay 1.5 m from the basket (box)
- Throw a tennis ball into the basket 15 times. You can do it with one arm or both.
- Count how many times ball aimed a basket.
- Please, repeat twice and put your results in the table.

Day	Completed (Tick)	Not Completed (Tick)	How many repetitions/sets did you do? Other comments?	
Day 1	☐	☐	1 set	2 set
Day 2	☐	☐	1 set	2 set
Day 3	☐	☐	1 set	2 set
Day 4	☐	☐	1 set	2 set
Day 5	☐	☐	1 set	2 set
Day 6	☐	☐	1 set	2 set

We'd like to know how much you enjoyed doing the exercises. Please circle the smiley that fits!



Home program - Task training group
Week 6
Child's name_____

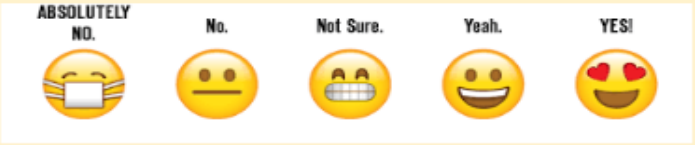
Exercise: The cross crawl

Description:

- Stand with feet comfortably apart
- Lift the left knee up and touch it with the right hand
- Then release the knee and and hand and return the foot to the ground
- Then repeat with the right knee up and touch with the left hand
- Perform this exercise 20 times, 1-3 sets

Day	Completed (Tick)	Not Completed (Tick)	How many repetitions/sets did you do? Other comments?
Day 1	☐	☐	
Day 2	☐	☐	
Day 3	☐	☐	
Day 4	☐	☐	
Day 5	☐	☐	
Day 6	☐	☐	

We'd like to know how much you enjoyed doing the exercises. Please circle the smiley that fits!



Home program - Task training group
Week 7
Child's name_____

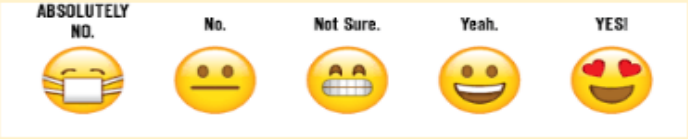
Exercise: Sit down with bean bag on top of your head

Description:

- Stand straight. Place the bean bag on top of your head.
- Sit down on floor with the bag balanced on top of your head
- Repeat 10 times
- Put in the table the number of trials when bean bag stayed on your head

Day	Completed (Tick)	Not Completed (Tick)	How many repetitions/sets did you do? Other comments?
Day 1	☐	☐	
Day 2	☐	☐	
Day 3	☐	☐	
Day 4	☐	☐	
Day 5	☐	☐	
Day 6	☐	☐	

We'd like to know how much you enjoyed doing the exercises. Please circle the smiley that fits!



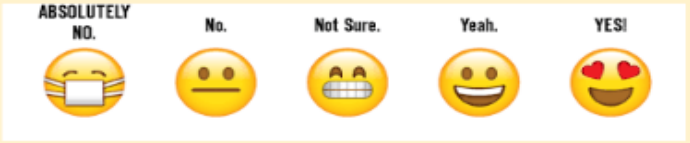
Home program - Task training group
Week 8
Child's name_____

Exercise: Rhythm jumping
Description:

- Stand with one foot on top of the ball (football, basketball, netball, etc.)
- Jump to the opposite side with the inside foot tapping the top of the ball
- Continue jumping. Try to get a rhythm
- Perform 10 jumping, take 10 secs rest, repeat again 10 times (that is 1 set).
- Complete 1-3 sets

Day	Completed (Tick)	Not Completed (Tick)	How many repetitions/sets did you do? Other comments?
Day 1	☐	☐	
Day 2	☐	☐	
Day 3	☐	☐	
Day 4	☐	☐	
Day 5	☐	☐	
Day 6	☐	☐	

We'd like to know how much you enjoyed doing the exercises. Please circle the smiley that fits!



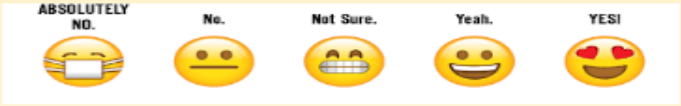
Home program - Strength training group
Week 1
Child's name_____
Exercise: Crab Walk

Description:

- Sit on the ground with your feet in a comfortable position
- Keep your palms behind your hips on the ground
- Keep your abs engaged and pull your body off the ground, with your weight balanced on your feet and hands
- Now, use your left foot and right hand to walk one step forward
- Repeat on the other side.
- Try to do as many steps as you can

Day	Completed (Tick)	Not Completed (Tick)	How many repetitions/sets did you do? Other comments?
Day 1	☐	☐	
Day 2	☐	☐	
Day 3	☐	☐	
Day 4	☐	☐	
Day 5	☐	☐	
Day 6	☐	☐	

We'd like to know how much you enjoyed doing the exercises. Please circle the smiley that fits!

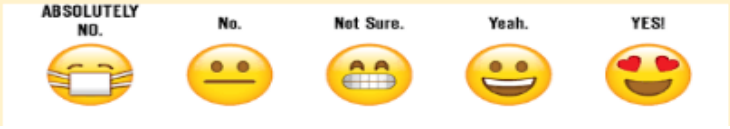


Home program - Strength training group
Week 2
Child's name_____
Exercise: Superman
Description:

- Lie on your tummy on the floor
- Imagine you are superman flying through the air with your arms and legs stretched out
- Try to hold it for as long as you can
- Perform as much sets as you can (up to 10). Put the number in the table

Day	Completed (Tick)	Not Completed (Tick)	How many repetitions/sets did you do? Other comments?
Day 1	☐	☐	
Day 2	☐	☐	
Day 3	☐	☐	
Day 4	☐	☐	
Day 5	☐	☐	
Day 6	☐	☐	

We'd like to know how much you enjoyed doing the exercises. Please circle the smiley that fits!



Home program - Strength training group

Week 3

Child's name_____

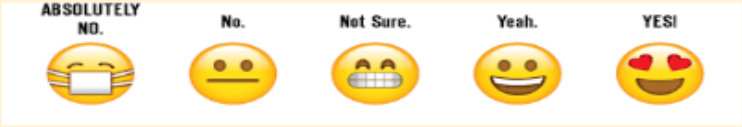
Exercise: Bridging

Description:

- Lay on your back with knees bent and feet flat on the floor
- Push hard through your heels to raise bottom up off the floor
- Keep your head and shoulders on the ground
- Exhale while you are raise your bottom
- Do 5- 10 reps and repeat 2-3 sets if you are willing to do this. Put the number of reps/sets into the table

Day	Completed (Tick)	Not Completed (Tick)	How many repetitions/sets did you do? Other comments?
Day 1	☐	☐	
Day 2	☐	☐	
Day 3	☐	☐	
Day 4	☐	☐	
Day 5	☐	☐	
Day 6	☐	☐	

We'd like to know how much you enjoyed doing the exercises. Please circle the smiley that fits!

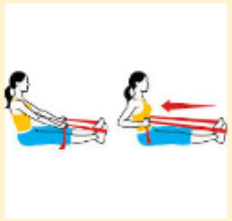


Home program - Strength training group

Week 4

Child's name_____

Exercise: Seated Row with theraband

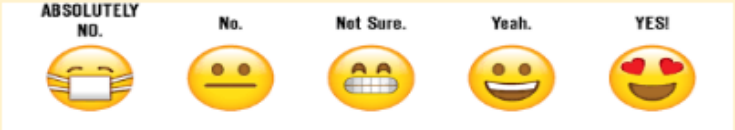


Description:

- Take a seat with legs extended, place the center of the band behind the soles of your feet.
- Grab the band with both hands, arms extended and palms facing each other.
- Sitting nice and tall, bend at the elbow and pull the band toward your core, squeezing your shoulder blades together.
- Slowly return to starting position and repeat 10 reps. If your are willing, you can repeat this set.

Day	Completed (Tick)	Not Completed (Tick)	How many repetitions/sets did you do? Other comments?
Day 1	☐	☐	
Day 2	☐	☐	
Day 3	☐	☐	
Day 4	☐	☐	
Day 5	☐	☐	
Day 6	☐	☐	

We'd like to know how much you enjoyed doing the exercises. Please circle the smiley that fits!

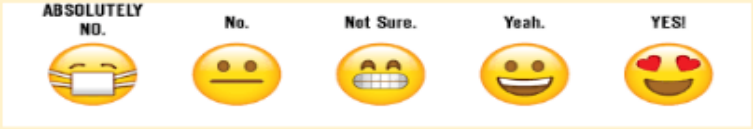


Home program - Strength training group
Week 5
Child's name_____
Exercise: Squats
Description:

- Stand about 15-20 cm in front of a chair with feet shoulder-width apart and toes pointed forward.
- With weight on the heels, slowly lower the hips until the butt taps the chair.
- Straighten legs and stand up.
- Make 10 repetitions. If you are willing, you can repeat this set

Day	Completed (Tick)	Not Completed (Tick)	How many repetitions/sets did you do? Other comments?
Day 1	☐	☐	
Day 2	☐	☐	
Day 3	☐	☐	
Day 4	☐	☐	
Day 5	☐	☐	
Day 6	☐	☐	

We'd like to know how much you enjoyed doing the exercises. Please circle the smiley that fits!



Home program - Strength training group

Week 6

Child's name_____

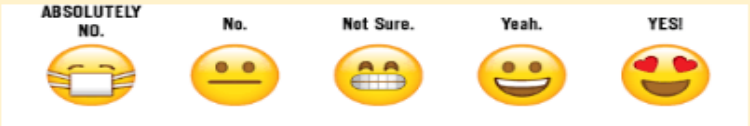
Exercise: Sit-ups

Description:

- Bend your knees while lying on the floor. You can put your feet under a coach or ask someone holds them. Put your hands by your ears or above your head
- Then you raise your back off the ground until you're in a seated position.
- Make 10 repetitions. If your are willing, you can repeat this set.
- To make the exercise easier you can hold your arms flat on the ground and to make it more difficult cross your arms across your chest.

Day	Completed (Tick)	Not Completed (Tick)	How many repetitions/sets did you do? Other comments?
Day 1	☐	☐	
Day 2	☐	☐	
Day 3	☐	☐	
Day 4	☐	☐	
Day 5	☐	☐	
Day 6	☐	☐	

We'd like to know how much you enjoyed doing the exercises. Please circle the smiley that fits!



Home program - Strength training group

Week 7

Child's name_____

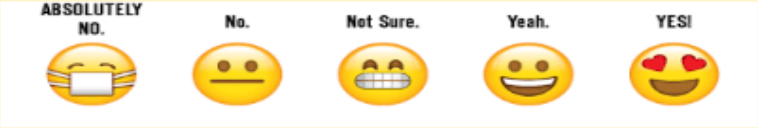
Exercise: Kneeling Push-ups

Description:

- Lie prone on floor with hands slightly wider than shoulder width.
- Bend knees and raise body up off floor by extending arms with body straight.
- Keeping body straight and knees bent, lower body to floor by bending arms. Push body up until arms are extended.
- Make 5-10 repetitions. If you are willing, you can perform one - two more sets.

Day	Completed (Tick)	Not Completed (Tick)	How many repetitions/sets did you do? Other comments?
Day 1	☐	☐	
Day 2	☐	☐	
Day 3	☐	☐	
Day 4	☐	☐	
Day 5	☐	☐	
Day 6	☐	☐	

We'd like to know how much you enjoyed doing the exercises. Please circle the smiley that fits!



Home program - Strength training group

Week 8

Child's name_____

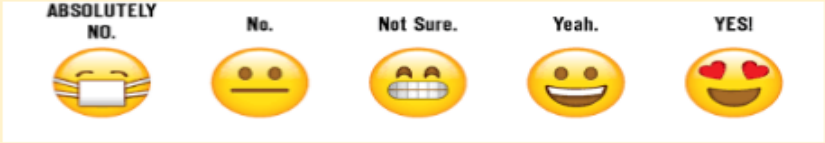
Exercise: Plank

Description:

- Lie down on your stomach with your legs extended and arms at your sides
- Bend your arms at the elbows, placing forearms to the side of your shoulders
- From here, push up off the ground, keeping back straight and parallel to the floor
- Try to keep this position on toes and forearms in this until you are fatigued.
- Please, timing (or ask someone's help to do this) and put it in the logbook

Day	Completed (Tick)	Not Completed (Tick)	How many repetitions/sets did you do? Other comments?
Day 1	☐	☐	
Day 2	☐	☐	
Day 3	☐	☐	
Day 4	☐	☐	
Day 5	☐	☐	
Day 6	☐	☐	

We'd like to know how much you enjoyed doing the exercises. Please circle the smiley that fits!



Appendix 11: Logbook instructions

Logbook
Instructions

Dear parent/caregiver(s),

The logbook has been designed to help keep record of your child's progress in completing a home exercise program.

1. Please be sure to fill out this form every day, whether your child performs an exercise or not. Just check the box in the correct table cell.
2. If you complete an exercise, please put the number of sets and repetitions
3. If don't complete an exercise, please indicate a reason in the column "Comments"
4. It's very important that the logbook if filled out honestly. There is no punishment for not performing exercises. Do not force your child to commit exercises, but feel free to remind them about the exercises (or encourage your child otherwise), but please, do not push them a lot.
5. At the bottom of the sheet, you can see a scale with smileys. Please ask your child to circle one of them to indicate how much they liked completing the exercises.
6. Please bring the logbook every week to the session.

Thank you again for your cooperation!