Title of Thesis:

Examining the effects of Ki-o-Rahi on the development of fundamental movement skills by children in Aotearoa New Zealand

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Abstract

Children with poor fundamental movement skills might have challenges when engaging in activities that require specific skills to help them perform effectively. Development of those skills through targeted training has the potential to build the foundation for fundamental movement skills. This study examined whether Ki-o-Rahi can enhance learning fundamental movement skills (FMS) and cognitive and social skills in Aotearoa New Zealand children. A quasi-experimental pre-post design was conducted over 8 weeks with 86 primary school children from five separate classes that were allocated to treatment conditions via cluster sampling: two classes to the intervention group, two to the control group, and one to the legend-only control group. The intervention group learned the legend and played Ki-o-Rahi over 8 sessions, whereas the control groups continued with their regular physical activities, but only one of the control groups learned the legend. FMS were measured using the Test of Gross Motor Development—Third Edition (TGMD-3) and the Motor Assessment Battery for Children (MABC-2). Cognitive skills were measured using the Head-Toes-Knees-Shoulders test (HTKS), forward and backward digit span, and forward and backward corsi block. Researchers measured social skills using the Early Childhood Social Relationship with Peers (ECSRP) teacher-proxy questionnaire. The results demonstrated that the intervention and control group gained improvements in the FMS and social skills but not cognitive skills. The legend-only group showed no significant changes. The findings suggest that Ki-o-rahi can contribute to developing FMS, cognitive, and social skills in Aotearoa New Zealand children. Future research should consider extending the duration of the study to assess long-term effects and include a larger cohort of Pacific or Māori children to explore potential benefits of Ki-o-Rahi in greater depth.

Keywords

Ki-o-Rahi, Fundamental movement skills, Cognitive development, Social skills, Aotearoa New Zealand Children.

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Glossary

Fundamental movement skills: group of motor behaviours that includes locomotor, object manipulation, and stability skills, such as, running, throwing, and balancing on one leg, respectively (Rudd et al., 2015).

Iwi: The largest political grouping in Māori society before European contact; a group of people connected by a common ancestor or ancestors; literal: bone; modern meaning: tribe (Taonui, 2005).

Kaitiakitanga: (guardian, protector)

Ki-o-Rahi: an umbrella term for a myriad of ancient Māori ball games that stem from the legend of Rahitutakahina and Tiarakurapakewai who were thought to be a married couple (Brown, 2007).

Māori: the indigenous peoples of Aotearoa New Zealand (ANZ)

Manaakitanga: (showing respect and hospitality)

Ragatiratanga: (leadership and strength)

Rautaki: (strategy, innovation, and intelligence).

Tikanga: correct procedure, custom, habit, lore, method, manner, rule, way, code, meaning, plan, practice, convention, protocol - the customary system of values and practices that have developed over time and are deeply embedded in the social context (www.netvalue.nz, 2013).

Wātea: open space.

List of abbreviations

ANZ: Aotearoa New Zealand

ASD: autism spectrum disorder

CSI-EC: Character Strengths Inventory for Early Childhood

ECSRP: Early Childhood Social Relationship with Peers

FMS: Fundamental movement skills

HTKS: Head, Toes, Knees, and Shoulders Test

MABC-2: Motor Assessment Battery for Children, Second Edition

PPDMF: Pacific Post-development Methodological Framework

PROMIS: Patient Report Outcome Measurement Information System

SCBE: Social Competence and Behaviour Evaluation

TGMD-3: Test of Gross Motor Development, Third Edition

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Chapter One: Introduction

Introduction

Children who have limited competence in executing fundamental movement skills (FMS) may experience challenges when interacting with their environment (Pitchford et al., 2021). Thus, the development of FMS is a vital component for children to engage with their environment. Mastering FMS can contribute to a child's physical, cognitive and social development, and is a crucial building block for an active lifestyle (Lubans et al., 2010). The relationship between developmental domains and FMS is notably stronger during childhood (Zeng et al., 2019), so it is important to develop FMS at an early stage to build a strong foundation for successful learning. Rudd et al. (2015) describe FMS as a "group of motor behaviours that includes locomotor, object manipulation, and stability skills, for example, running, throwing, and balancing on one leg, respectively" (p.2). FMS are the building blocks of more advanced, complex movements required to participate in sports, games, and other context-specific physical activity (Logan et al., 2017). Motor development is divided into gross and fine motor skills. Gross motor skills involve the use of larger muscles for running or walking, and fine motor skills involve the use of smaller muscles for writing or drawing (Gonzalez et al., 2019). Children who develop these skills early in childhood can benefit from improving their physical health as well as building a foundation for future engagement in sports (Sumich, 2013). Studies show that children who develop FMS at an earlier stage in life have advantages over those who learn later. Those benefits include injury reduction, improved sports performance, physical literacy, health enhancement, brain development, and long-term fitness (e.g., Lubans et al., 2010). Studies also show that children who were not FMS competent had lower levels of cardiorespiratory fitness and physical activity (Lubans et al., 2010). Additionally, Hardy et al. (2012) found that rates of FMS competency among students in Grade Four (ages nine to ten years old) tended to be low due to students' socioeconomic status, cultural background, cardiorespiratory fitness, and physical activity levels. Further, that same study found that children with low levels of FMS competency were less likely to engage in a wide range of physical activities when compared with children with higher levels of FMS competency. Van

Abswoude et al. (2021) states that engaging in sports, exercise, and physical activity is crucial for overall health and well-being as it fosters the growth of FMS and cognitive skills. Early development of FMS, for example, is associated with superior cognitive development (Roebers et al., 2014), which is linked to greater academic success later in life (Roeber, 2013; Niederer, 2011). This suggests that, overall, investing in early childhood FMS interventions is important for children's successful participation in games and sports, and these skills are reattained for life.

Longitudinal studies have revealed that motor functions at the age of five and six years can predict social behaviours one year later and social status amongst peers two years later. For instance, Bart (2007) found that children's motor functions were predictive of their social behaviours and social status in the first grade (ages six or seven), and that children with better motor abilities showed positive social behaviours, whereas, children with poorer abilities experienced social difficulties (also see Ommundsen, 2010). Furthermore, children with poor FMS are reported to have lower levels of social play, social status, increased social anxiety, and poorer emotional comprehension (Piek, 2008; Bar-Haim, 2006).

Complex skills are acquired through sports and social activity; however, children can perform those complex skills by developing foundational skills, which are developed through the development of FMS. Therefore, if children have a solid foundation of FMS, they are proficient in executing complex skills in the physical activities and sports in which they participate, thereby highlighting the importance of developing those fundamental skills.

Xin et al. (2020) conducted a systematic review of studies on preschool-aged children and found a strong association between specific FMS components and physical activity intensity, emphasising the importance of FMS for physical development and promotion of interactive experiences. That study also suggested that sports associated with cultural connections provide an additional lens for understanding and diversity, and have the power to unite the participants to their culture while playing the game.

Ki-o-Rahi, a culturally important high intensity team-based ball game unique to Māori – the indigenous peoples of Aotearoa New Zealand – is believed to provide a culturally-based FMS development experience (Capio et al., 2017). To explore that potential, this chapter will overview the literature on FMS and its union with student learning together with Ki-o-Rahi. This will be followed by an explanation of the study design and methodology, providing the foundations of a game-based intervention to test whether Ki-o-Rahi can improve FMS in children and, in turn, improve cognitive and social development.

Skills and competencies

Skills, competencies, and other components contribute to a child's chances of successful learning. The Aotearoa New Zealand curriculum integrates competencies, such as self-management, participation, contribution, relation, language use, symbols text, and thinking to equip students with necessary skills and values (Ministry of Education, 2018). Students who actively engage in the learning process are significantly more competent at understanding how they learn and how their skills and thoughts develop over time (Hipkins & Bolstand, 2007). Halloran (2022) states that " children ages five and six prefer playing with friends rather than on their own, being able to demonstrate empathy, speaking and conveying simple stories in complete sentences, and engaging in cooperative play" (p. ??). This range of developmental milestones can also be achieved through participation in game play with friends during in class group tasks and recess.

Ki-o-Rahi

Ki-o-Rahi is an umbrella term for a myriad of ancient Māori ball games that stem from the legend of Rahitutakahina and Tiarakurapakewai, who were thought to be a married couple (Brown, 2007). The legend demonstrates that Ki-o-Rahi is more than just a game; it is a testament to Māori culture, language, and stories passed down through generations (Ki-o-Rahi.com, n.d.). Ki-o-Rahi is played on beaches and open spaces called wātea (today ātea), with the rules and customs varying across different iwi (people) and tribal areas. It is fast-paced and integrates skills that are common to various sports, including handball, netball, and rugby tag. According to Capio et al., (2017), Ki-o-Rahi consists of transferable skills linked to FMS that have not yet been thoroughly investigated. The study utilised frame-by-frame video analysis to assess the movement skills required to play Ki-o-Rahi. These skills include four locomotor skills (run, jump, slide, leap), and four object control skills (kick, catch, overhand throw, underhand throw). Additionally, advanced skills (dodging, diving, blocking, and two-handed throwing) were also identified. Overall, the findings provide a foundation for Ki-o-Rahi as a context based FMS training programme for children and coaches. In the game context, FMS includes running, catching a Kī (soft foam ball), throwing the Kī at the Tupu (barrel drum placed as a target in the middle of the playing field), and passing the Kī to teammates. Figure 1 shows the Ki-o-Rahi field layout, which comprises a circular field

inclusive of different zones. To assist clarity, Figure 2 shows a new Ki-o-Rahi field recently installed at Fairfield High School in Hamilton, Aotearoa New Zealand.

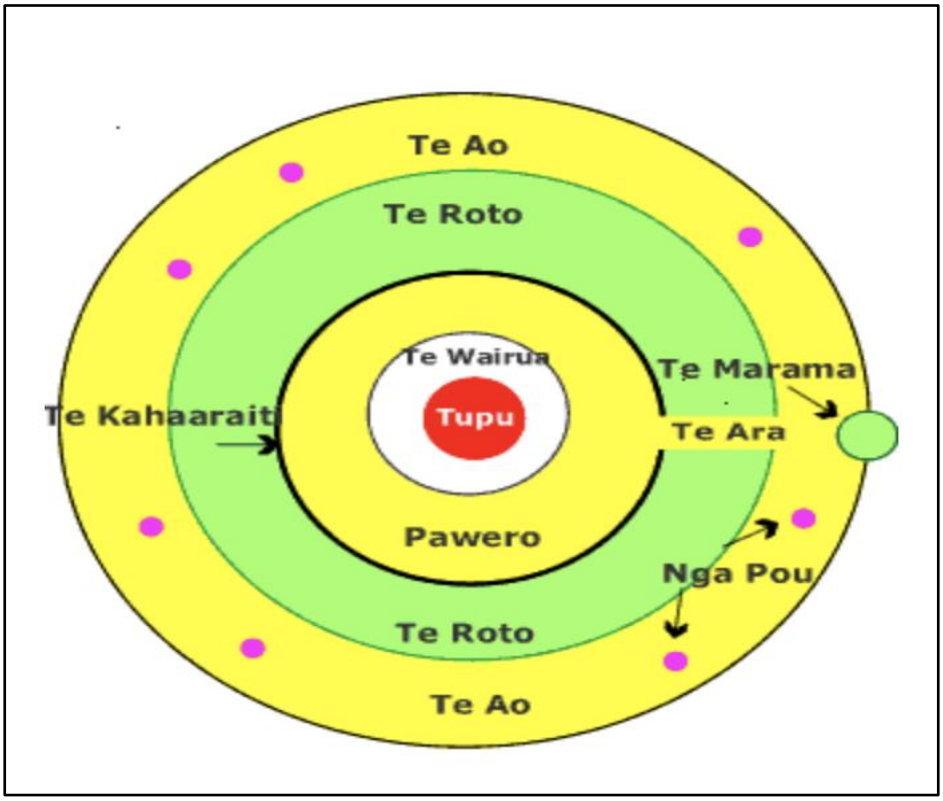

Figure 1 *Ki-o-Rahi field layout*

Note: New Zealand in History – Playing Ki-o-Rahi, n.d..

Figure 2 *Fairfield High School Ki-o-Rahi field*

Note: Aporosa, 2023.

Ki-o-Rahi is played between two teams, Kioma and Taniwha. In competitive games, each team consists of seven players; however, in recreational or physical education settings, teams can consist of any number of players. In games played by children, teams often have designated tags that are attached to a Velcro belt wrapped around their waist, as shown in Figure 3. In this example, Kioma are wearing red tags and Taniwha yellow tags.

Figure 3 *Designated team tags*

Note: Murdoch, 2023

On the Ki-o-Rahi field, there are different zones that each team is allowed to enter. Kioma are only permitted to enter the Te Marama (Moon) zone, which is also where the game starts. Te Ao (an area that represents land/forest) is the outer zone, Pawero is the central zone (an area that represents the desert), and Te Ara (the ice bridge fording Te Roto) is where the Kaitiaki (guardian) can move in and out of the Pawero.

Taniwha team members are not permitted to cross Te Ara (ice bridge), but instead must remain in Te Ao (forest/world area) or Te Roto (an area of the Ki-o-Rahi field representing a water-filled lake area). The Kioma team is allowed to run through Te Roto only after they have touched one or more Nga Pou with the Kī. Without achieving this, they are not permitted to enter Te Roto and proceed into the Pawero.

Each team has their own objectives (Brown, 2010). Kioma players gain points by successfully touching one of the seven Nga Pou with the Kī they are holding in their hands. Once they have touched the pou, they can turn that successful touch into a try by placing the ball down in the Pawero. A try is awarded one point if one Nga Pou is contacted, two points if two different Nga Pou are contacted, and so on up to a maximum of seven points. Every time

a try is scored, the game is restarted from the Te Marama. If the team drops the ball or gets one of their bands ripped in Te Roto, they immediately lose possession and the Kī is given to the Taniwha team. In the Te Ao zone, when a Kioma player's tag has been ripped they have three seconds to pass the ball to their team mates, however if the time limit is exceeded, the ball is given to the Taniwha team. The Kioma team is considered to be the Kaitiaki (guardians) of the Pawero and no more than a maximum of three members of the Kioma team must defend the Tupu from the Kī being thrown by the Taniwha team.

Taniwha players score points by throwing or kicking the ball onto the tupu for one point. If a point is scored, play carries on. On defence their aim is to rip off tags from the belts of their opponents, preventing the opposing team from retaining possession or scoring points. Teams alternate the roles of Kioma and Taniwha at half or quarter time during a game played for four quarters or two halves of a set time.

Ki-o-Rahi as a team sport, FMS and learning

Team sports require players to communicate with each other to help coordinate what actions will take place, ensuring all team members are working in unison. Additionally, discussing strategies to gain points or prevent opposing teams from gaining points also plays an important role in communication learning. Communication is therefore an essential component of teamplay. Further, teammates support one another by offering encouragement and motivation.

Team sports also play an important role in bringing together individuals from a variety of backgrounds and skills, which also promotes relational qualities, such as empathy, creativity, and sociability, leading to inclusivity and understandings about diversity (Ghildiyal, 2015). Team sports increase the likelihood of health improvement when compared with individual activity sports, particularly through improvements to self-esteem and social interaction (Elime et al., 2013). Yu et al.'s (2018) study, exemplifies this. Their work utilised a game-based exercise training programme for children with autism spectrum disorder (ASD), designed to improve psychological and physical traits. The findings showed that the implementation of the game-based method offered an integrated approach fostering the psychological and physical development of children with ASD, thereby positively impacting there overall wellbeing and skill development.

Ki-o-Rahi is argued to be ideal for the development of cognitive skills in young players. This is achieved by increasing children's skills through situation evaluation, and encouraging them to decide how best to adjust their strategies to fit those situations and in turn solve

problems. Additionally, through the child's ability to observe and maintain rules and apply strategies learned in play, they can then apply those skills to later games, which also assists in building memory. According to Memmert (2011), creative development is an important aspect of cognitive skill development in the early stages of life. In other words, children have greater ability to develop and improve their skills when younger.

In a study by Wawrzyniak et al. (2022), who utilised the 'Eduball' method (i.e., the use of educational balls with printed letters, numbers, and signs enhances physical fitness while also enhancing mathematical and language skills), core academic subjects can be integrated with physical education to improve student motor and cognitive skills. The Eduball method was shown to significantly improve primary school student's cognitive and motor skills. Considering the psychological and physical traits involved in playing Ki-o-Rahi, the game may provide an effective option for assisting children in developing their social, cognitive, and motor skills. Additionally, it promotes cultural awareness and understanding and gives players a way to connect with Māori culture and tikanga values. That tikanga includes Kaitiakitanga (guardian, protector), Manaakitanga (showing respect and hospitality), Rangatiratanga (leadership and strength), Kotahitanga (unity, collectiveness) and Rautaki (strategy, innovation, and intelligence).

The game of Ki-o-Rahi is unique in that it is based on the Maori legends of Rahitutakahina and Tiarakurapakewai. This legend demonstrates that Ki-o-Rahi is more than a game; it is a testament to Māori culture, language, and stories passed down through generations. There are many various versions of the narrative of Tiara and Rahi; each legend's story is unique, yet they all share some common characteristics. The legend can be summarised as follows: Rahi journeys to rescue his beloved Tiara from the patupaiarehe (fairy people). The patupaiarehe cast spells to prevent Rahi from catching up with them. Rahi and his tribe eventually arrived at the entrance to the cave where Tiara was being held at the foot of the mountains. Rahi and his tribe attempted to rescue Tiara by blocking the vents and luring the other tribe out. When the cave filled up with smoke, they were forced to run out, with Tiara among them. Both tribes congregate on the shore where Rahi was stranded, and he decides to make peace with the other tribe. Here, on these shores, the two tribal councils created a way for ensuring lasting peace. They developed a game to commemorate Tiara's attempted kidnapping, which the tribes played together to protect the peace. As the children play the game through the legend, it is beneficial for them. It provides a fun and interactive way to understand the legend. Additionally, they can learn different tikanga values within the legend, which are demonstrated through the game. In our study, we had control groups with and without hearing the legend to

isolate the effects of the legend itself on the testing outcomes. Furthermore, it provides us with a different lens on different groups testing outcomes to see if it does make a difference in the children's testing performance if they heard the legend or not.

The objectives of the game of Ki-o-Rahi promote social development as it encourages children with a lower level of social skills to interact and take part in the game. These are achieved by having teammates pass the Kī to them, giving them the opportunity to run with it, or throw it at the Tupu. Teamwork and cooperation, in which each player is able to get involved and work together to score points or to prevent the opposing team from gaining points, are some of the benefits that team sports promote in helping develop social skills.

This study will seek to fill the knowledge gap and investigate whether there is a correlation between Ki-o-Rahi and improved FMS in young children. To do this, a two-arm quasi-experimental study will be conducted among new entrant/year 1 children aged five and six years old from a local Waikato primary school.

The study aims to measure three outcomes: physical development, cognitive development and social development through the use of various test measures explained in the upcoming methods section. The study is important as it has the potential to benefit children and their lifestyle through improved FMS, learning, social and cultural interaction. Additionally, it will make a valuable contribution to the existing literature on a topic that has received little empirical investigation. For instance, there is a lack of research on a younger target audience, limited studies on children's FMS in New Zealand, and limited focus on children of different ethnicities. Although research shows FMS should be developed in children at a younger age to enhance their cognitive and social skills, FMS are often taught in isolation (for instance, throw-then-catch), failing to integrate these skills into real-world scenarios. Therefore, this leads to the question of whether FMS can be learned by playing a traditional Māori ball game, Ki-o-Rahi. Ki-o-Rahi allows children to freely participate with support from teachers and friends, with few restrictive rules. Additionally the study will determine whether the game helps transfer competencies and developmental milestones to children, promoting continuous learning and success. Integrating FMS development into school curricula may enhance children's skills; however, the findings of the study will determine if this is valid.

The objective of this study is to examine if Ki-o-Rahi can be utilised to develop FMS in Aotearoa New Zealand children and if it can contribute to effective cognitive and social skill development. It is hypothesised that children in the intervention group will have a higher improvement in their physical, cognitive, and social development outcomes compared to children in the control groups. It is anticipated that the study will contribute to a broader

understanding of the impacts and significant role that developing FMS plays in Aotearoa New Zealand children's physical, social, and cognitive skills. Additionally, it is anticipated that this will provide evidence on the use of approaches, such as Ki-o-Rahi, to train FMS in schools. The following section explains the methods used to test the hypothesis.

Chapter Two: Methods

2.1. Methodology

The study was guided by the Pacific Post-development Methodological Framework (PPDMF). The framework draws on Pacific respect values and cultural practices to support the ethical and equitable use among people or groups not included in the norming and standardising of those measures (Aporosa et al., 2021). This methodology was chosen as I am of Fijian ancestry and the study included non-European participants. With the PDMF underpinned by respect, this also provides utility among non-Pacific research participants (Aporosa, 2014, p. 87).

2.1.1 Ethics

The study was assessed by the Human Research Ethics Committee of the University of Waikato and ethical permission was provided to conduct the study (HREC(HECS)2023#4). This is attached in Appendix A.

2.2 Participants

Eighty-six primary school children were recruited from a local primary school in Hamilton, Aotearoa New Zealand. After exclusions, seventy-three participants were included in the analysis (35 males and 38 females; mean age = 75.78 months; SD = 4.289). Ten participants were excluded due to absence during the pre-, post-, and follow-up tests. Eleven participants were away on holiday, moved schools, or underwent surgery; one participant could not complete most tests, and another withdrew during the intervention. Children aged five to six were recruited because this is when basic movement skills start to develop (Australian Capital Territory Government, 2019). Child ethnicity is reported in Table 1. Written informed consent was obtained from parents or carers before data collection, and children verbally confirmed their consent. Five separate classes of first-year children participated in the study. Two classrooms were allocated to the intervention group (read the legend and play the game; N = 29), two to the control group (did not read the legend and did not play the game; N = 30), and one to the legend-only group (only read the legend; N = 14).

Table 1. Children Ethnicity Report

Ethnicity	*n*
New Zealand Māori	6
Pacific Islander	1
New Zealand European	25
American European	1
African/African Origins	6
East Asian	8
European	2
Middle Eastern	1
Mixed	5
South Asian	16
South East Asian	2

2.3 Study Design

This study used a quasi-experimental pre-post design to assess the impact on the development of fundamental movement skills. The intervention group engaged in both hearing/learning the legend and playing the game of Ki-o-Rahi and was compared to two control groups. The first control group heard/learned the legend but did not play the game, while the second control group neither heard the legend nor played the game. Both control classes received regular physical activity classes as usual. Test measures were selected to assess changes in motor skills (e.g., fundamental movement skills), cognitive skills (e.g., executive functioning, visual and spatial working memory), and social skills from pre- to post-intervention period. Those test measures will now be explained.

2.3.1. Test of Gross Motor Development – Third Edition (TGMD-3)

The Test of Gross Motor Development – Third Edition (TGMD-3) is a criterion-referenced instrument that measures proficiency in two subtests: locomotor skills (run, gallop, hop, skip, horizontal jump, slide) and ball skills (kick a stationary ball, overhand throw, underhand throw, one-hand stationary dribble, two-hand catch, strike with a bat) (Ulrich, 2017). TGMD-3 is commonly used to assess fundamental movement skills (FMS) of children aged between three to ten years (Maïano et al., 2022; Kelly et al., 2021). Test-retest reliability for the TMGD-3 demonstrated high intra-class correlation coefficient (ICC) agreements for locomotor (ICC = 0.97), ball skills (ICC = 0.95), and total TGMD-3 (ICC = 0.97, Webster & Ulrich, 2017). TMGD-3 also demonstrated good content validity (i.e., raw scores improved with increasing age) and acceptable construct validity (RMSEA = 0.10, Webster & Ulrich, 2017). This assessment and Motor Assessment Battery for Children (MABC-2) were selected as they evaluate a child's movement skills and physical development.

Children received a short version of the TGMD-3 test, which included three locomotor skills (run, gallop, hop) and four ball skills (two-handed ball strike, two-hand catch, kick, and overhand throw). This was adapted from Valentini et al. (2018) who developed a short-form version of the TGMD-2 with six skills (run, gallop, hop, two-handed strike, kick, overhand throw). The two-hand catch skill was included in the testing as this skill can be utilised and performed in Ki-o-Rahi.

For each of the skills, children completed one practice trial followed by two scored trials. Each skill within the subtest includes specific performance criteria, for example, for the running criteria, "arms move in opposite to legs with elbow bent; brief period where both feet are off the surface; narrow foot placement landing on heel or toes (not flat-footed); and non-support leg bent about 90 degrees so foot is close to buttocks". The child receives 1 point for each of the criteria that is achieved. The scores for each skill within the subtest are then summed for a raw skill subtest score, ranging from 0 – 12 for locomotor skills and 0 – 16 for ball skills.

2.2.2. Motor Assessment Battery for Children (MABC-2)

Because the TGMD-3 does not assess balance, the static/dynamic balance subtest from the Motor Assessment Battery for Children – Second Edition (MABC-2, (Henderson et al., 2015) was used. The full test includes three subtests (manual dexterity, ball skills, static/dynamic balance), and has been designed to evaluate motor functioning across a variety of fine and gross motor skills for children aged four to twelve years (Engel-Yeger et al., 2010). MABC-2 is a revised version of the original Movement Assessment Battery for Children (MABC), which

has been adapted to include three age bands (three – six years, seven – ten years, and 11 – 16 years; Schulz et al., 2011). Ghayour Najafabadi et al., (2022) reported that the MABC-2 test had an ICC total score of 0.83, which indicates a high level of reliability.

The static/dynamic balance subtest has three items: one-leg balance, walking heels raise. Each child completed one practice trial and two scored trials. For the one-leg balance, the child stood on one leg (right or left) on the mat with their arms hanging freely at their sides. A second trial was not necessary if the child-maintained balance for a whole 30 seconds. For walking heels raised, the child walked along a 4.5-meter tape down line with their heels raised. A second trial was not necessary if the child successfully completed 15 consecutive steps or reached the end of the line without making a mistake (e.g., walking outside of the line, dropping heels). For jumping on mats, the child stood on the first mat and then jumped consecutively forward with their feet together until the last mat. A second trial was not necessary if the child completed five consecutive jumps without making any mistakes (e.g., landing outside of the mat, landing with one leg first).

2.2.3. Head-Toes-Knees-Shoulders (HTKS)

The Head-Toes-Knees-Shoulders (HTKS) measure is an instructional game in which children are asked to do the opposite of what the examiner says. It is designed to measure executive functioning, such as inhibitory control (i.e., children must prevent themselves from following the examiner's instruction), working memory (i.e., children must remember the task's rules), and attention focusing (i.e., children must focus their attention on the examiner's instructions) (Cameron Ponitz et al., 2008). HTKS is appropriate for children between the ages of four and eight years (Hee et al., 2018). Children were given a set of guidelines to follow in the HTKS task. In part one, the children had to touch their toes when the examiner said, "touch your head", and they had to touch their heads when the examiner said "touch your toes". Similar guidelines were outlined in part two, but different actions were required (e.g., children were required to touch their shoulders when told to touch their knees and their knees when told to touch their shoulders. Each item was graded on a three-point scale: 0 for incorrect responses (i.e., child did not do the opposite of what the examiner said), 1 for self-corrected responses (i.e., child initiated an incorrect response but corrected themselves), and 2 for correct responses (i.e., child did the opposite of what the examiner said). Participants were given six practice items and ten test items in part one. In part two, they were given five practice items and ten test items. The final score is the sum of first six practice items and the twenty test items (range 0 - 52; Meador et al., 2013). HTKS has been shown to be a reliable and valid method of measuring

executive control in children (McClelland et al., 2021), an ICC total score of 0.90 which indicates a high value reliability (McClelland et al., 2014).

This assessment, together with the Forward and Backward Digit Span, and Forward and Backward Corsi Block, which will be explained shortly, was selected as it provides a comprehensive assessment of cognitive development in children by testing a variety of cognitive processes, such as attention, working memory, and spatial memory.

2.2.4. Forward and Backward Digit Span

The digit span test was developed to measure a person's verbal working memory and short-term memory (Woods et al., 2011). The Wechsler Intelligence Scale for Children – Third Edition (WISC-III; Wechsler & Kodama 1949) introduced the test, which is performed in two subtests: forward and backward (Visu-Petra et al., 2009). The children were given (verbally) a sequence of random numbers by the examiner and were asked to repeat (verbally) the sequence back in the same order (forward) or in the reverse order (backward). Two trials were given at each sequence length, starting with a two-digit sequence and up to an eight-digit sequence. If the recall was correct on one or more trials for each sequence length, then the sequence length increased by one item. The order of the subtests was counterbalanced with scores ranging from 0 – 16 per subtest. The digit span tests show high internal reliability of 0.70 – 0.90 (Conway et al., 2005).

2.2.5. Forward and Backward Corsi Block

The Corsi block test was developed as a nonverbal analogue to the Hebb recurring digit paradigm and as a way to measure spatial memory with minimal verbal mediation (Berch et al., 1998). The test consists of two subtests, forward and backward, which can be administered to participants ranging in age from six to 80 years. The procedure for the forward and backward Corsi block test was the same as the forward and backward digit span test except that the sequence of blocks being tapped had to be recalled instead of numbers. Like the digit span task, the order of the subtests was counterbalanced with the scores ranging from zero – 16 per subtest. The Corsi block test demonstrates moderate reliability (de Paula et al., 2016).

2.2.6. Early Childhood Social Relationship with Peers (ECSRP) teacher-proxy

We developed a 15-item questionnaire to be completed by the class teacher of each child, and this was completed at pre-test and post-test. The questionnaire was designed to assess social skills, especially social relationships with peers (aged 4 to 6 years, see Appendix B). The items were adapted from three questionnaires – The Patient Report Outcome Measurement

Information System (PROMIS, (Varni et al., 2012), Social Competence and Behaviour Evaluation (SCBE, (LaFreniere & Dumas, 1996), and Character Strengths Inventory for Early Childhood (CSI-EC, (Shoshani, 2019). The questionnaire items were composed of key Tikanga values that were highlighted from the Legend of Rahitutakahina (Rahi) and Tiarakurapakewai (Tiara), those values included Kaitiakitanga (guardian, protector), Manaakitanga (showing respect, hospitality), Rangatiratanga (leadership, strength), and Rautaki (strategy, innovative, intelligent). We chose these values based on the characteristics demonstrated by the characters and in parts of the legend story. Additionally, these values can be demonstrated in social activities, and individuals may display any of these values when interacting with their peers. The values included in this questionnaire contribute to the cultural aspect. When children hear and learn these values from the story, they can apply them in their interactions with others. Moreover, the Tikanga values can be implemented and reinforced in the intervention to serve as a constant reminder for the children. Providing examples from the legend can assist the children in demonstrating these values during the intervention. The importance of these specific values to be used for the questionnaire is that it builds on the connection from the story into real-world scenarios where these Tikanga values can be illustrated. Each of these values is also reflected within the Māori culture; understanding these values through this lens can help the children understand and learn these values. Respectful of teachers is a question in the questionnaire that reflects the Tikanga value of Manaakitanga (showing respect, hospitality); Rangatiratanga (leadership, strength) is reflected through the question of tending to be the leader in group activities with other children; Kaitiakitanga (guardian, protector) is reflected through the question of always volunteering to help when s/he sees someone in need; Rautaki (strategy, innovative, intelligent) is reflected through the question of seeking to resolve conflicts peacefully.

2.3. Procedure

The study had three stages: pre-test, intervention period, and post-test. During the pre-test and post-test, the children completed all six of the measures (locomotor skills, ball skills, static/dynamic balance, HTKS, forward and backward digit span test, forward and backward Corsi block test). Testing took place at the local primary school during school hours. Testing stations for the motor tasks (locomotor skills, ball skills, static/dynamic balance) were set up in a quiet area of the playground (outside) by two examiners (one administered and rated and the other only rated). Testing stations for the cognitive tasks (HTKS, forward and backward

digit span, forward and back Corsi block) were conducted by one examiner, with the child seated. Two children were excused from class to complete testing and the children took turns completing each task – while one child completed one of the motor tasks, the other child completed one of the cognitive tasks – which were administered in random order.

Class teachers completed our 15-item questionnaire before and after the intervention and the school provided basic demographics (e.g., date of birth, ethnicity) and special learning needs (e.g., English as second language, learning disability) of the students. This was done over two weeks before (pre-test) and after (post-test) the intervention.

In the intervention group, teachers read the legend of Rahitutakahina (Rahi) and Tiarakurapakewai (Tiara) to the children (Day 1). On the following day, the testers introduced the game of Ki-o-Rahi to the children and outlined how the story was linked to the game (Day 2). The legend and the rules of the game were simplified to accommodate the comprehension skills of young children. Over the course of four weeks, the intervention groups played Ki-o-Rahi twice a week (a total of 8 times). In the control group, teachers continued their normal physical education classes as usual and therefore the children did not read the legend or the game. In the legend only group, teachers read the legend to the children, but the testers did not return on the following day to introduce the game, and therefore the children only head the legend but not play the game. See Appendix C for Ki-o-Rahi field setup instructions.

2.3. Data analysis

To assess changes in fundamental movement skills, locomotor skills, and ball skills, the subscales of the TGMD-3 short form were analysed using a three way omnibus ANOVA with repeated measures on the first two factors: 3 (time: pre-test, post-test, follow-up test) x 3 (task: run, gallop, hop) x 3 (group: intervention, control, story only control). Static and dynamic balance tests were analysed using a two-way ANOVA with repeated measures on the first factor: 3 (time: pre-test, post-test, follow-up) x 3 (group: intervention, control, story only control). To assess changes in cognitive skills, executive function (i.e., HTKS test) was assessed using a two-way ANOVA with repeated measures on the first factor: 3 (time: pre-test, post-test, follow-up) x 3 (group: intervention, control, story only control), while visual-spatial working memory (i.e., Corsi block test) was analysed using a three-way ANOVA with repeated measures on the first two factors: 3 (time: pre-test, post-test, follow-up test) x 2 (task: forwards, backwards) x 3 (group: intervention, control, story only control). Verbal working memory (i.e.,

digit recall task) was analysed using a two-way ANOVA with repeated measures on the first two factors: 3 (time: pre-test, post-test, follow-up test) x 2 (task: forwards and backwards) x 3 (group: intervention, control, story only control). Last, to assess changes in social skills (i.e., the ECSRP questionnaire), a two-way ANOVA was performed with repeated measures on the first factor: 3 (time: pre-test, post-test, follow-up test) x 3 (group: intervention, control, story only control). Studies have shown gender differences in FMS proficiency (see Zheng et al., 2022), cognitive abilities (e.g., Mohammed & Fine, 2015), and social skills (e.g., Hajovsky et al., 2021; Mohammed, 2016; Walker, 2010), so gender was entered as a covariate in all analyses. Significant effects were further investigated using follow-up ANOVAs or planned comparison pairwise *t*-tests with Bonferroni correction where appropriate. Effect sizes were reported as partial eta squared. Statistical testing was performed in SPSS, with an alpha level of $p < 0.05$ adopted for all comparisons.

2.4 Summary

This chapter drew on literature to provide an overview of FMS and their importance in children's development. The study utilized a Māori ball game, Ki-o-Rahi, and various tests to assess children's FMS, focusing on physical, cognitive, and social development outcomes. Participants aged five and six were assessed in order to test the study hypothesis, which is that children in the intervention group will have a higher improvement in their physical, cognitive, and social development outcomes compared to children in the control groups. The following chapter presents the data analysis, followed by a discussion of the findings from the study.

The study utilises the Pacific Post-Development Methodological Framework (PPDMF) combined with a quasi-experimental design to assess the outcome measures of physical, cognitive, and social development in participants aged five and six years old. The study hypothesis was that children in the intervention group will display greater improvement in their physical, cognitive, and social development outcomes compared to children in the control groups.

Chapter Three: Results

3.1 Dependent ratings

In the study, since only one rater (MW) rated all pre-test, post-test, and follow-up sessions, we chose to use only MW's measurements. The scores of the second rater, who rated a sample of participants from the pre-test, post-test, and follow-up tests, were used to confirm the accuracy of the ratings provided by the primary rater (MW) (Pearson's $r = 0.695$, $p < 0.001$). There were missing data in 7.2% of cases. As a result, we calculated the raw scores for these cases by computing data points through a statistical technique called multiple imputations. The final sample consisted of 73 participants who were eligible for analysis.

3.2 Test of Gross Motor Development – Third Edition (TGMD-3)

The analysis of the locomotor tasks revealed no main effect of time, $F(2, 138) = 2.975$, $p = 0.054$, $\eta_p^2 = 0.041$, but there was a visual trend towards improvement in children's locomotor skills throughout the study. A main effect of task was found, $F(2, 138) = 14.909$, $p < 0.001$, $\eta_p^2 = 0.178$, suggesting significant differences in mean scores among the tasks (run, gallop, hop). Follow-up pairwise comparisons revealed that running had significantly higher scores compared to galloping, $M = 1.950$, $SE = 0.166$, $p < 0.001$, 95% CI [1.543, 2.356], and hopping, $M = 1.805$, $SE = 0.179$, $p < 0.001$, 95% CI [1.366, 2.244]. See Figure 4 for a graphical representation of the mean scores for each task.

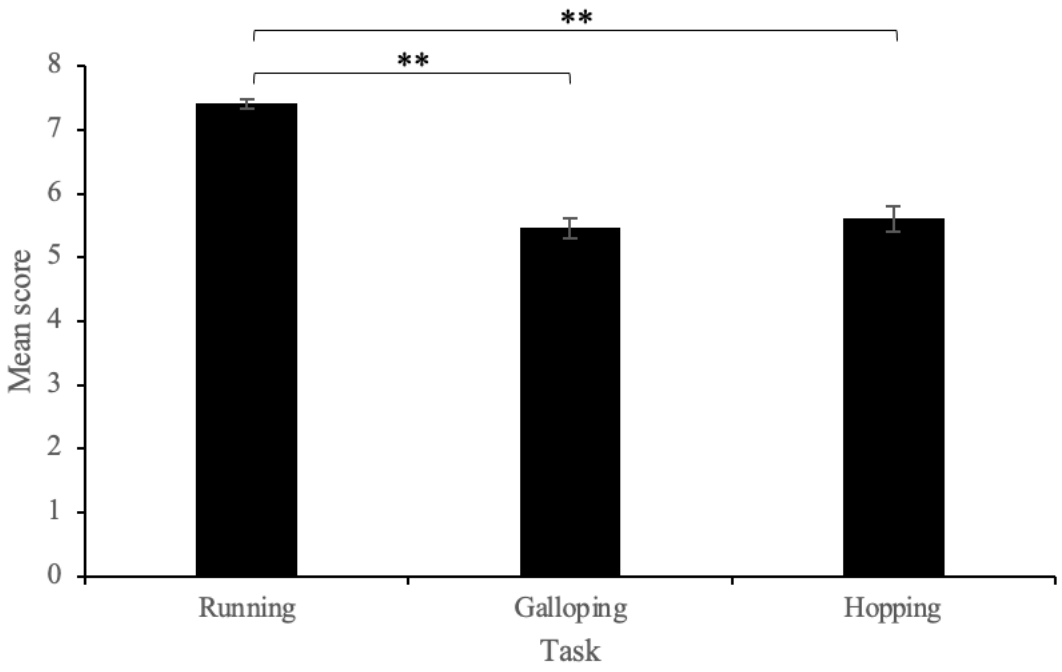

Figure 4. *Mean scores of each task.*

Note: (**) p value less than .01

A time x group interaction was observed, F(4, 138) = 3.178, p = 0.016, η_p^2 = 0.084, indicating differential changes in scores across time points for different groups. For the intervention group, there was a significant increase in scores from pre-test to post-test, M = 1.287, SE = 0.313, p < 0.001, 95% CI [0.519, 2.055], and from pre-test to follow-up test, M = 1.606, SE = 0.235, p < 0.001, 95% CI [1.029, 2.184]. However, there was no significant difference from post-test to follow-up test, M = 0.320, SE = 0.247, p = 0.600, 95% CI [-0.286, 0.925]. In contrast, the control group showed no significant increase in scores from pre-test to post-test, M = 0.154, SE = 0.307, p > 0.99, 95% CI [-0.600, 0.907]. Nevertheless, there was a significant increase from pre-test to follow-up, M = 0.837, SE = 0.231, p = 0.002, 95% CI [0.270, 1.403], and from post-test to follow-up test, M = 0.683, SE = 0.242, p = 0.019, 95% CI [0.089, 1.277]. No significant changes were observed in the scores of the legend-only control group across different time points (pre-test to post-test, M = 0.048, SE = 0.449, p > 0.99, 95% CI [-1.054, 1.150]; pre-test to follow-up test, M = 0.542, SE = 0.338, p = 0.340, 95% CI [-0.287, 1.371]; post-test to follow-up test, M = 0.494, SE = 0.354, p = 0.503, 95% CI [-0.375, 0.363]). Refer to Figure 5 for an illustration of the mean score

comparison across the different groups. No main or interaction effect of gender was found (p's > 0.050).

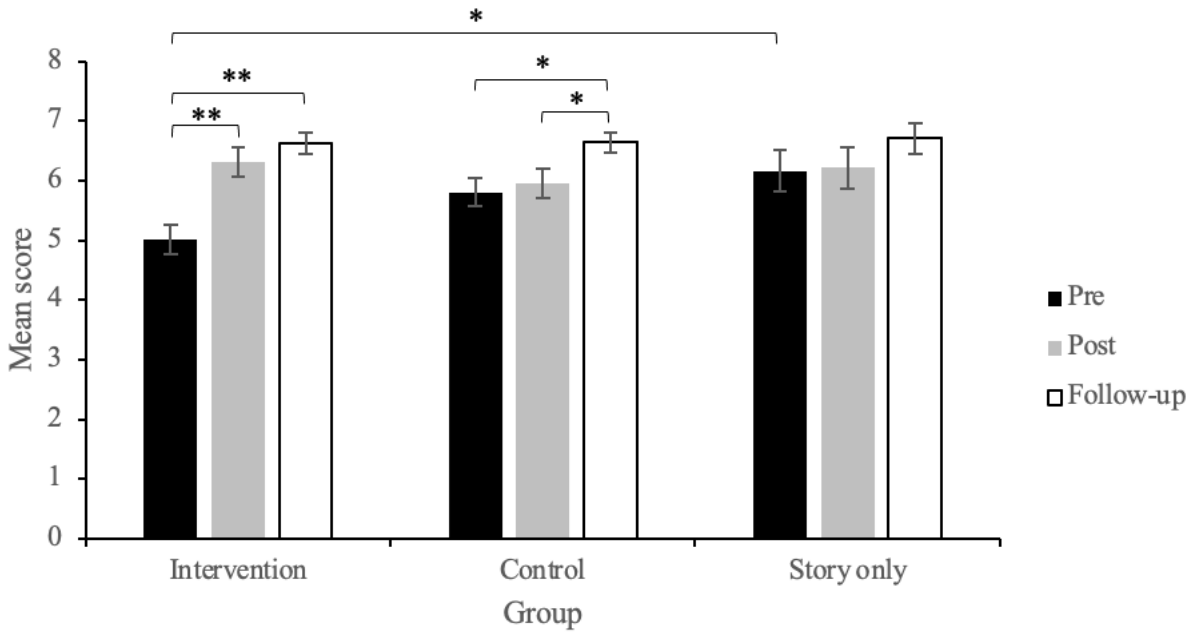

Figure 5. *Mean scores comparison across the three groups.*

Note: (**) p values less than .01, (*) p values less than .05

3.2.1 Ball Skills

Ball skills task analysis indicated that there were no main effects for time, F(2, 138) = 1.972, p = 0.143, η_p^2 = 0.028, or, group F(2, 69) = 0.607, p = 0.548, η_p^2 = 0.017. However, significant main effects were found for task, F(2, 138) = 7.751, p < 0.001, η_p^2 = 0.101. Figure 6 illustrates the mean scores for each task. A follow-up pairwise comparison showed that catching scores were significantly lower compared to kicking, M = 0.823, SE = 0.160, p < 0.001, 95% CI [0.430, 1.216] and throwing, M = 0.899, SE = 0.209, p < 0.001, 95% CI [0.386, 1.412].

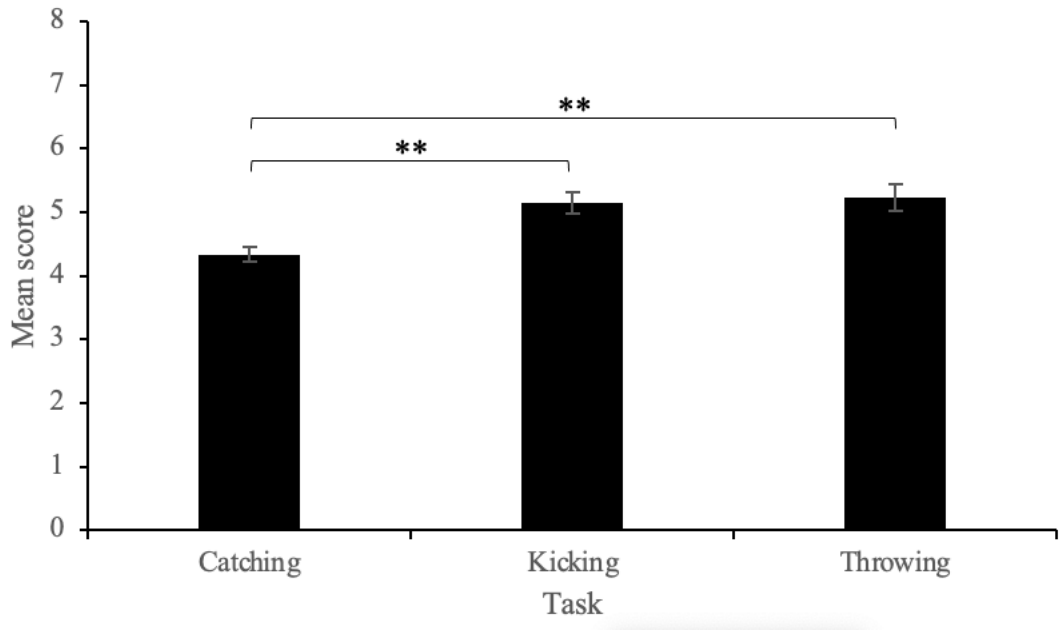

Figure 6. Mean Scorers of Ball Skill Tasks (Catching, Kicking, and Throwing)
Note: ** p value less .01

There were no interaction effects for time x group, $F(4, 138) = 1.438$, $p = 0.225$, $\eta_p^2 = 0.040$, time x task $F(4, 276) = 0.628$, $p = 0.643$, $\eta_p^2 = 0.009$, task x group $F(4, 138) = 0.386$, $p = 0.818$, $\eta_p^2 = 0.011$. A three-way interaction was not evident for time x task x group, $F(8, 276) = 1.394$, $p = 0.199$, $\eta_p^2 = 0.039$. Gender had a significant effect, $F(1, 69) = 4.626$, $p = 0.035$, $\eta_p^2 = 0.063$, with boys having higher scores compared to girls. Despite the lack of a significant three-way interaction, Figure 7 displays scores for the intervention and control groups.

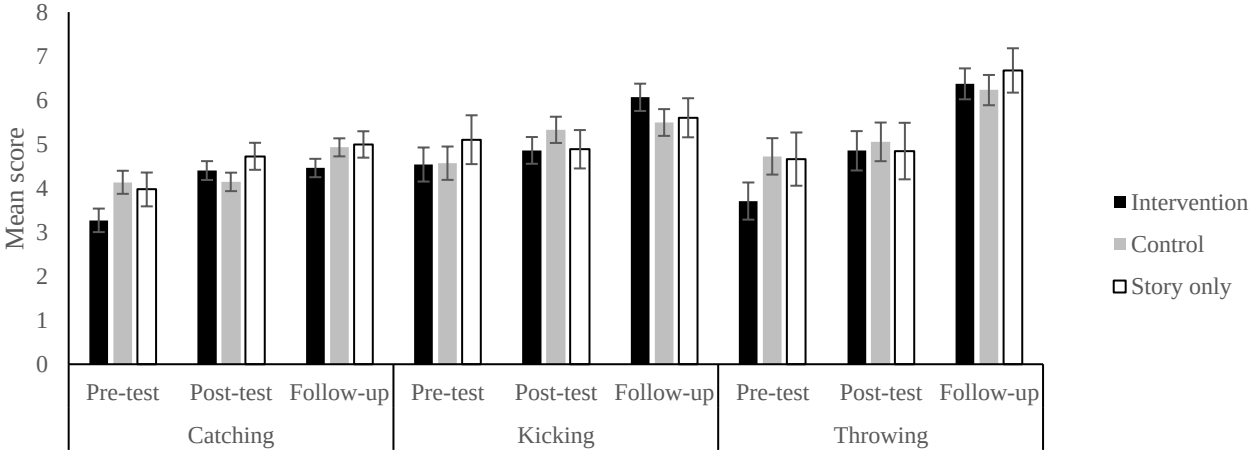

Figure 7. *Mean scores of ball skills tasks for intervention, control, and story only groups across pre-test, post-test, and follow-up test*

3.3. Motor Assessment Battery for Children (MABC-2)

3.3.1 Static balance:

The static balance analysis indicated that there were no main effects for time, $F(2, 138) = 1.256$, $p = 0.288$, $\eta_p^2 = 0.018$, or group, $F(2, 69) = 1.373$, $p = 0.260$, $\eta_p^2 = 0.038$. There was no interaction for time x group, $F(4, 138) = 1.331$, $p = 0.261$, $\eta_p^2 = 0.037$. Although there was not a two-way interaction, both the intervention group and the control group showed increases from pre-test to follow-up and from post-test to follow-up, whereas there was no difference across the time points for the legend-only control group. Figure 8 illustrates the mean time score of each group. There was no effect of gender (p's > 0.050).

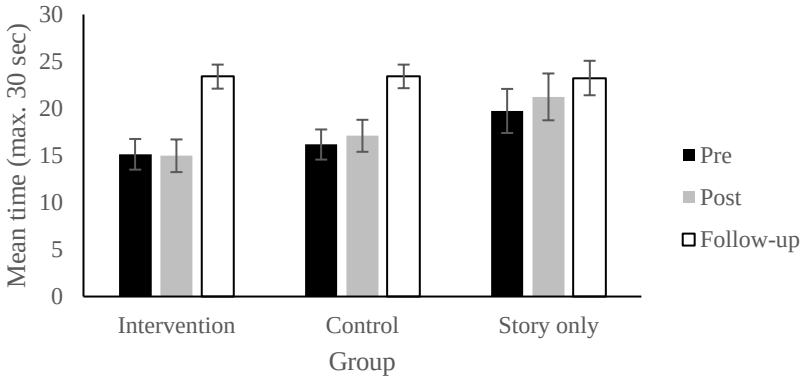

Figure 8. Mean time scores of the groups.

3.3.2 Dynamic balance:

The analysis of the dynamic balance indicated that there were no main effects for time, $F(2, 138) = 1.260$, $p = 0.287$, $\eta_p^2 = 0.018$, or group, $F(2, 69) = 0.353$, $p = 0.704$, $\eta_p^2 = 0.010$, as indicated in Figure 9, which shows the mean steps scores of each group. Additionally, there was no interaction effect for time x group, $F(4, 138) = 0.720$, $p = 0.580$, $\eta_p^2 = 0.020$. This suggests that there were minimal changes over the study's duration. Examining the intervention group's performance showed a clear improvement from pre-test to follow-up test; however, the follow-up analysis was not conducted for the dynamic balance. There were no effects of gender (p's > 0.050).

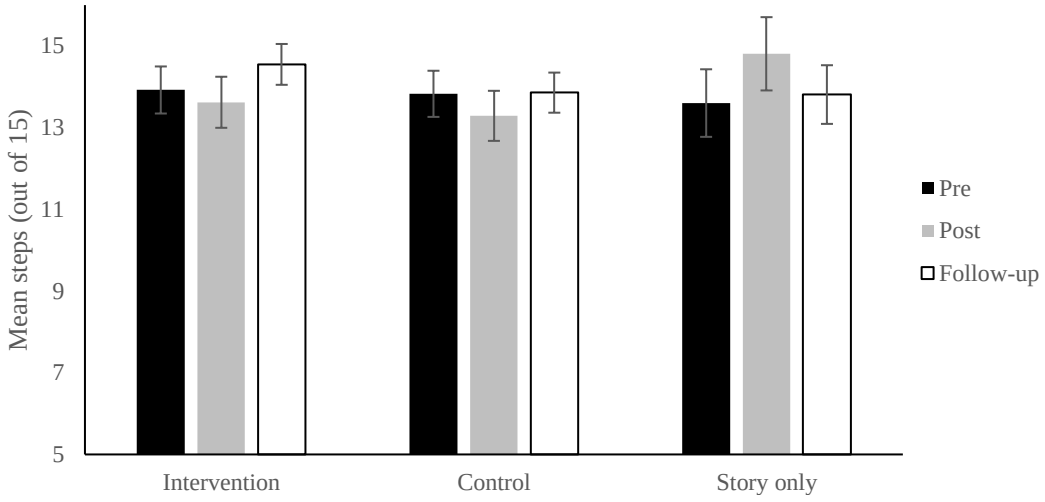

Figure 9*. Mean steps scores of groups.*

3.4 Cognitive Tests

3.4.1 Head-Toes-Knees-Shoulders (HTKS)

The HTKS test analysis indicated that there was a significant main of time $F(2, 136) = 8.471$, $p < 0.001$, $\eta_p^2 = 0.111$. The pairwise comparison analysis showed that there were significant increases in HTKS scores from pre-test to post-test, M = 6.071, SE = 1.015, $p < 0.001$, 95% CI [3.581, 8.561], pre-test to follow-up test, M = 8.924, SE = 1.034, $p < 0.001$, 95% CI [6.385, 11.463], and post-test to follow-up test, M = 2.853, SE = 0.909, $p = 0.008$, 95% CI [0.622, 5.083], Figure 10 illustrates this. Group also had a significant main effect, $F(2, 68) = 3.275$, $p = 0.044$, $\eta_p^2 = 0.088$. however, the pairwise comparison showed that there were no significant differences between intervention group and control group, M = 4.179, SE = 1.759, $p = 0.061$, 95% CI [-0.139, 8.497], intervention group and legend-only group, mean difference = 0.229, SE = 2.172, $p > 0.99$, 95% CI [-5.102, 5.560], and control group and legend-only group, M = 3.950, SE = 2.163, $p = 0.217$, 95% CI [-1.360, 9.260]; Figure 11 illustrates this. Additionally there were no interaction effects of time x group $F(4, 136) = 1.127$, $p = 0.346$, $\eta_p^2 = 0.032$, and no effects of gender (p's > 0.050).

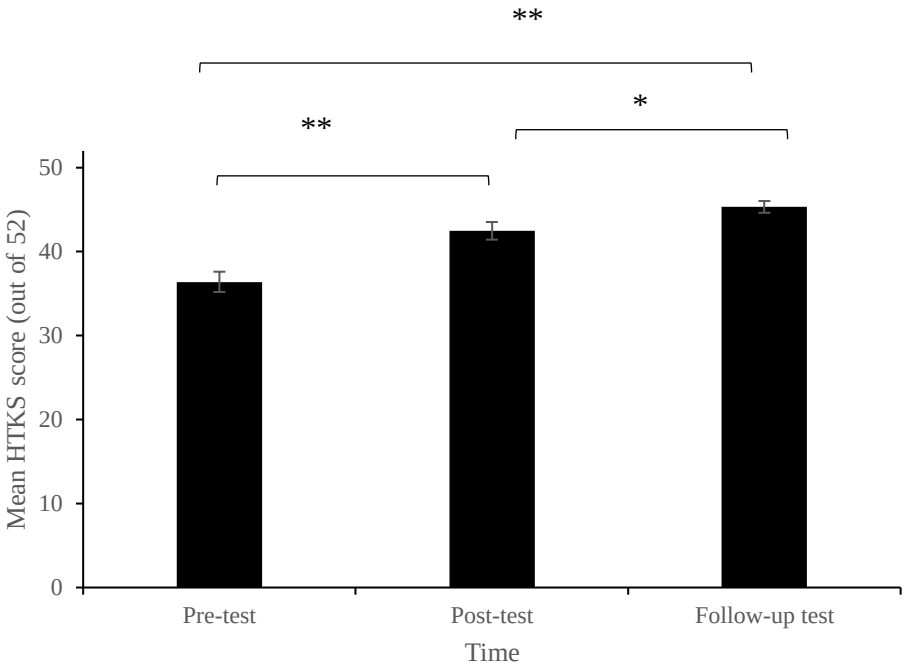

Figure 10. *Mean HTKS scores over the three testing times.*

Note: (**) p values less .01, (*) p value less .05

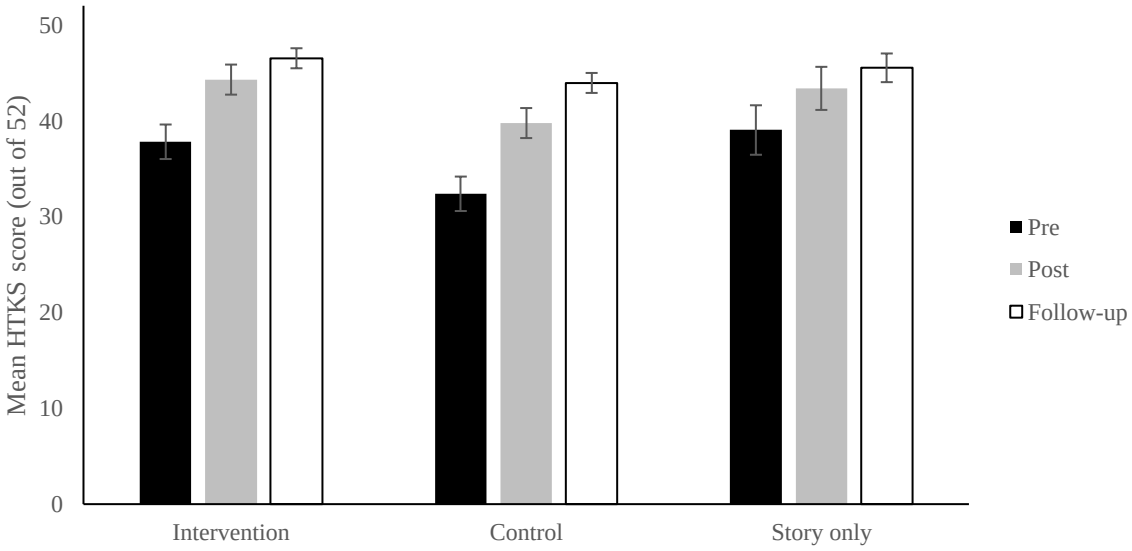

Figure 11. Mean HTKS scores of the groups.

3.4.2 Corsi block test

Corsi block test analysis indicated that there were significant main effects of time, $F(2, 138) = 3.375$, $p = 0.037$, $\eta_p^2 = 0.047$, and task, $F(1, 69) = 6.509$, $p = 0.013$, $\eta p^2 = 0.086$. The pairwise comparisons showed a significant increase in corsi block test scores from pre-test to post-test, M = 0.417, SE = 0.138, $p = 0.011$, 95% CI [0.078, 0.755] and from pre-test to follow-up test, M = 0.760, SE = 0.156, $p < 0.001$, 95% CI [0.376, 1.144]. However, from post-test to follow-up test, there was no significant increase, M = 0.344, SE = 0.172, $p = 0.148$, 95% CI [-0.078, 0.765]. This is illustrated in Figure 12. Additionally, there were significantly higher scores during the corsi block forward task compared to the backward task, M = 2.017, SE = 0.154, $p < 0.001$, 95% CI [1.709, 2.325]. Figure 13 illustrates this. There were no main effects of group, $F(2, 69) = 0.731$, $p = 0.485$, $\eta_p^2 = 0.021$. There was no effect of gender (p's > 0.050).

There were no interaction effects for time x group, $F(4, 138) = 0.022$, $p = 0.999$, $\eta_p^2 = 0.001$, task x group, $F(2, 69) = 1.065$, $p = 0.350$, $\eta_p^2 = 0.030$, time x task $F(2, 138) = 1.187$, $p = 0.308$, $\eta_p^2 = 0.017$, or time x task x group, $F(4, 138) = 1.032$, $p = 0.393$, $\eta_p^2 = 0.029$.

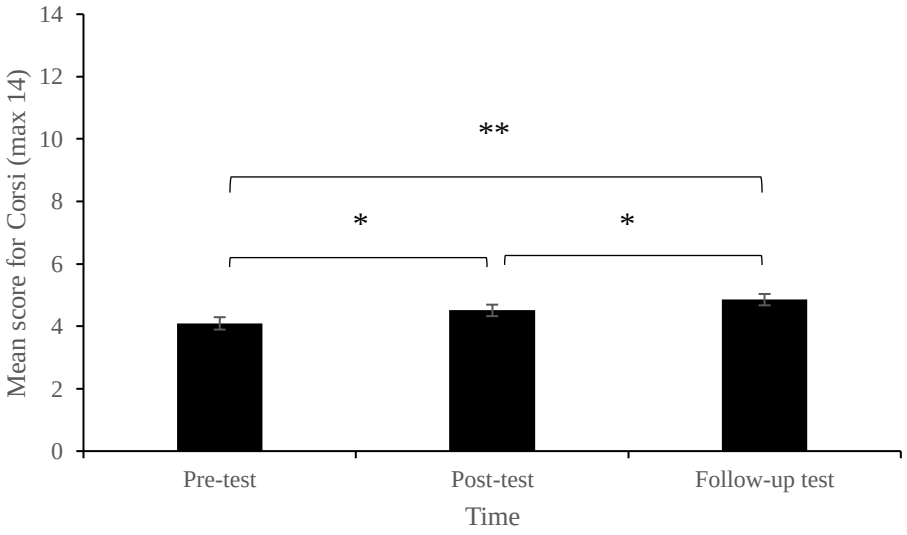

Figure 12. *Mean scores for Corsi over the three testing times.*

Note: (**) p values less .01, (*) p value less .05

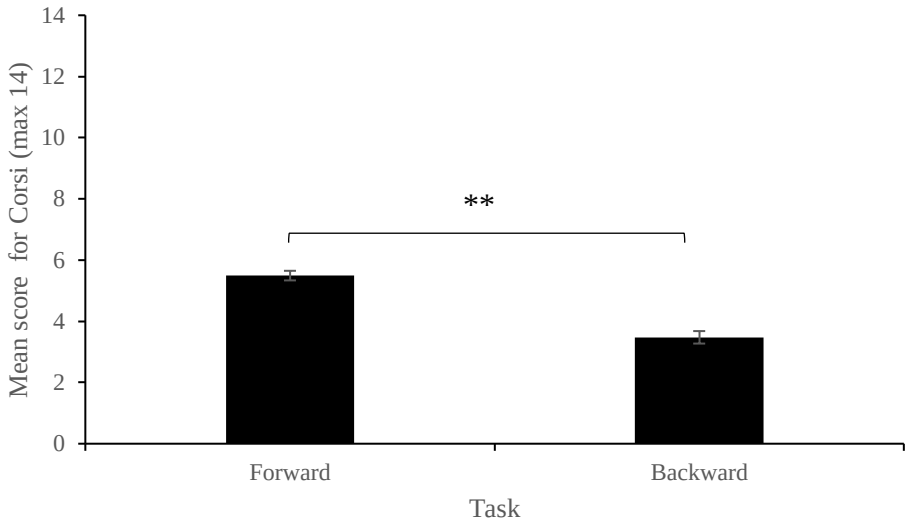

Figure 13 *Mean scores for Corsi forward and backward task.*

3.4.3 Digit recall test

The analysis of the digit recall test indicated that there was a significant main effect of task, $F(1, 66) = 75.177$, $p < 0.001$, $\eta_p^2 = 0.533$. However, there were no main effects of time, $F(2, 132) = 0.451$, $p = 0.638$, $\eta_p^2 = 0.007$, or group, $F(2, 66) = 2.059$, $p = 0.136$, $\eta_p^2 = 0.059$. Pairwise comparisons for the main effect of task identified significantly higher scores during the forward task compared to the backward task (M = 4.331, SE = 0.142, $p < 0.001$, 95% CI [4.047, 4.615]), as illustrated in Figure 14.

There were no interaction effects for time x group $F(4, 132) = 1.327$, $p = 0.263$, $\eta_p^2 = 0.039$, task x group $F(2, 66) = 0.167$, $p = 0.846$, $\eta_p^2 = 0.005$, time x task $F(2, 132) = 2.078$, $p = 0.129$, $\eta_p^2 = 0.031$, and time x task x group $F(4, 132) = 1.932$, $p = 0.109$, $\eta_p^2 = 0.055$. There was no effect of gender (p's > 0.050).

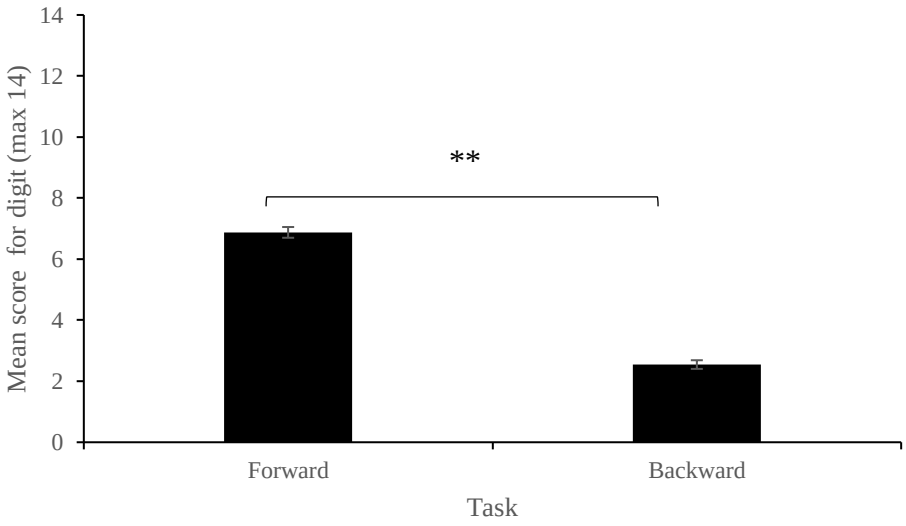

Figure 14. *Mean digit scores of forward and backward task*

Note: (**) p values less .01

3.5 Social skills test

The analysis of the social skills test indicated a significant main effect of time, $F(2, 120) = 4.523$, $p = 0.013$, $\eta_p^2 = 0.070$. Pairwise comparisons revealed a significant increase in social skills scores from pre-test to post-test ($M = 4.444$, $SE = 0.780$, $p < 0.001$, 95% CI [2.522, 6.366]), pre-test to follow-up test ($M = 7.533$, $SE = 0.733$, $p < 0.001$, 95% CI [5.726, 9.339]), and post-test to follow-up test ($M = 3.089$, $SE = 0.793$, $p < 0.001$, 95% CI [1.136, 5.041]). This is illustrated in Figure 15.

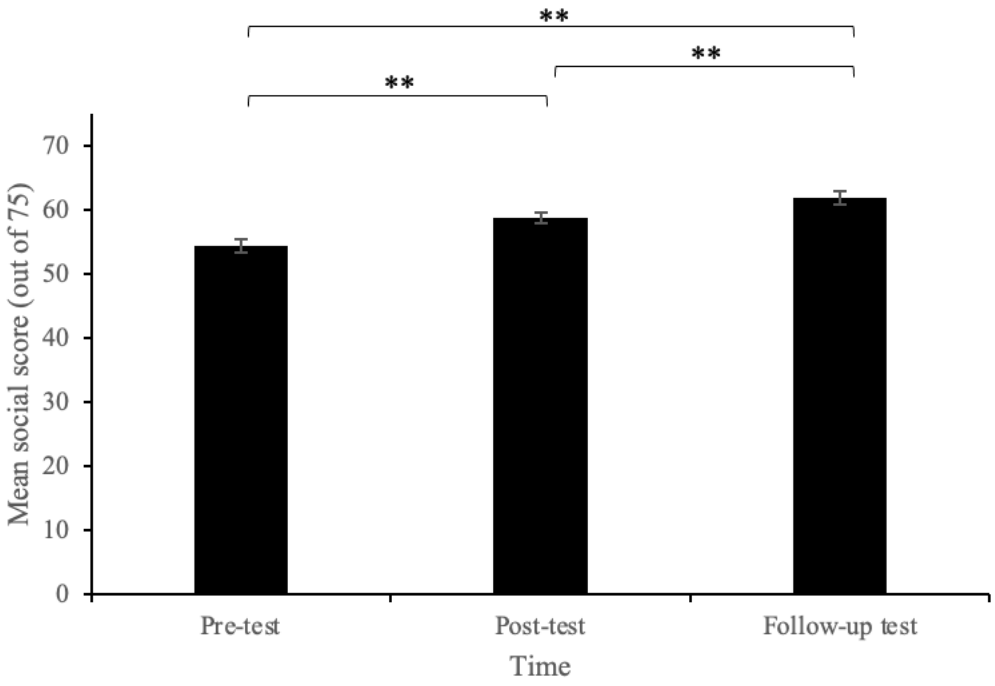

Figure 15. *Mean. Social scores of the testing times.*
Note: (**) p values less .01

There was no main effect for group, F(2, 60) = 2.827, $p = 0.067$, $\eta_p^2 = 0.086$, but an interaction was found for time x group, F(4, 120) = 9.927, $p < 0.001$, $\eta_p^2 = 0.249$ (see Figure 16). The intervention group showed a significant increase in social skills scores from pre-test to post-test, M = 9.511, SE = 1.166, $p < 0.001$, 95% CI [6.638, 12.383] and from pre-test to follow-up test, M = 11.740, SE = 1.096, $p < 0.001$, 95% CI [9.041, 14.440]. However, there was no significant increase from post-test to follow-up test, M = 2.230, SE = 1.185, $p = 0.194$, 95% CI [-0.689, 5.149]. The control group showed a significant increase in social skills scores from pre-test to post-test, M = 5.301, SE = 1.263, $p < 0.001$, 95% CI [2.192, 8.411], from pre-test to follow-up test, M = 9.223, SE = 1.187, $p < 0.001$, 95% CI [6.300, 12.146], and from post-test to follow-up test, M = 3.922, SE = 1.283, $p = 0.010$, 95% CI [0.762, 7.081]. In the legend-only group, there were no significant changes in social skills scores from pre-test to post-test, M = 1.480, SE = 1.605, $p > 0.99$, 95% CI [-2.474, 5.434], from pre-test to follow-up test, M = 1.634, SE = 1.509, $p = 0.849$, 95% CI [-2.082, 5.350], or from post-test to follow-up test, M = 3.114, SE = 1.631, $p = 0.183$, 95% CI [-0.904, 7.132].

Additionally, the intervention group had significantly lower scores compared to the legend-only control group in the pre-test, M = 12.178, SE = 2.608, $p < 0.001$, 95% CI [5.755, 18.601],

but not in the post-test, M = 1.187, SE = 2.297, $p > 0.99$, 95% CI [-4.469, 6.844 or follow-up test M = 2.071, SE = 2.633, $p > 0.99$, 95% CI [-4.412, 8.555]. The control group had significantly lower scores compared to the legend-only group in the pre-test, M = 6.953, SE = 2.676, $p = 0.035$, 95% CI [0.362, 13.544], but not in the post-test, M = 0.172, SE = 2.357, $p > 0.99$, 95% CI [-5.633, 5.976] or in the follow-up test, M = -0.636, SE = 2.701, $p > 0.99$, 95% CI [-7.290, 6.018]. The statistical analysis found no significant effects of gender (p > 0.050)

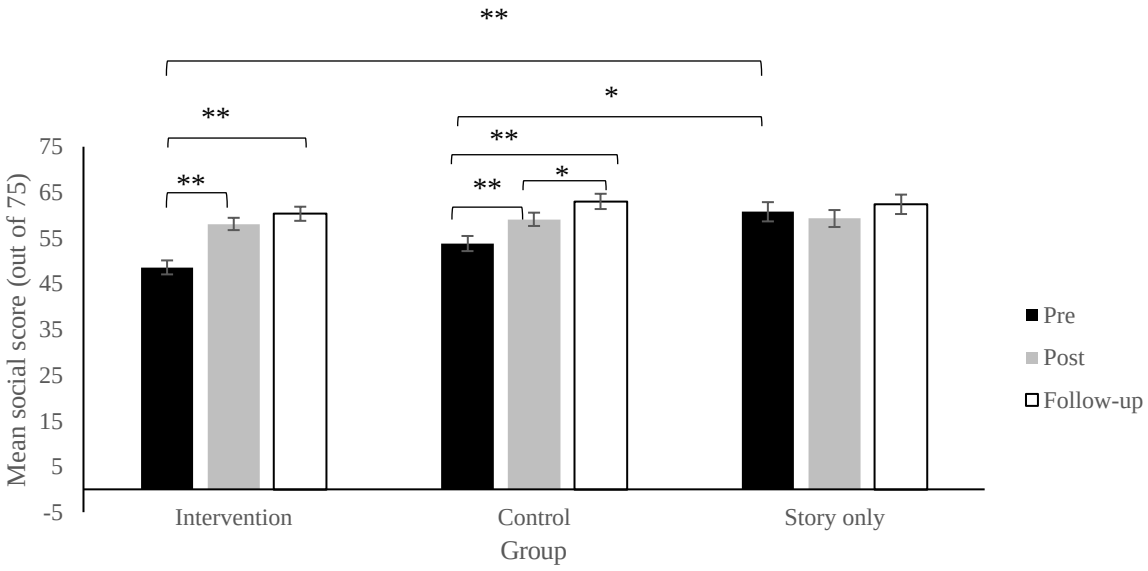

Figure 16. Mean social scores of the groups.

Note: (**) p values less .01, (*) p value less .05

Chapter Four: Discussion

Children who have a deficit in their FMS may struggle to perform and engage with their day to day activities, which may include playing sports, physical games with peers and so forth. However, developing their skills earlier may provide a solid foundation for enhancing their physical, cognitive and social skills. The study aimed to explore if Ki-o-Rahi can be utilised to develop FMS in Aotearoa New Zealand children, and also contribute to effective development of cognitive and social skills. The major findings that were identified in our results showed significant improvements in locomotor and social skills, and also showed improvements in some tasks and others did not have significant changes over time

4.1 Test of Gross Motor Skills – Fourth Edition (TGMD-4)

Children's locomotor skills showed significant improvements. The intervention group revealed a significant increase from the pre-to-post and pre-to follow-up tests. Sutapa et al. (2021) found a significant improvement in motor skills, particularly in locomotor skills, after a 12-week intervention with a goal-orientated play activity in early childhood. The improvement patterns observed in the intervention group before and after the intervention align with the findings of our study. The control group showed a gradual improvement over time, suggesting that continued practice could lead to enhancement. It aligns with the Vickers & Altman (2001) study, which focused on a longitudinal study on the development of gross motor skills in children with learning disabilities. It showed improvement over time for children that are typically developed, and that was due to practice and familiarity. The study suggests that regular physical activity and ongoing practice could assist in the development of children locomotor skills, which does align with my observation of the control group's findings. In relation to the tasks conducted in the locomotor test, it was indicated in the findings that running had significantly higher scores compared to galloping and hopping. It is plausible that galloping and hopping may be more complex skills that require more practice to perform well. Also, they are skills that are not usually used as a daily function, whereas running is a daily function and would be a simple skill to perform. Schmutz et al. (2020) discussed the differences in biomechanical and physical demands between running, galloping, and hopping. Children easily master and achieve higher scores in running since it requires less complex coordination and energy effort. The interaction effect between time and group indicates that the intervention

likely had a greater impact on motor skills than the control group, which did not show any improvements until the follow-up. The intervention group was exposed to more running, which may have increased familiarity and improved scores in their locomotor tasks. In contrast, the control group showed delayed improvement, possibly influenced by other factors such as activities during or outside of school. Lubans et al. (2010) conducted a review examining how control groups frequently exhibit delayed improvement in motor skills, possibly influenced by regular physical activity or healthy developmental processes. It brings attention to the differences between the significant increase from focused interventions and the more gradual increase displayed in control groups as a result of factors like task familiarity and competence.

4.1.2 Ball Skills

In the ball skills task, there was a significant difference in performance between the tasks, with catching scores being lower than those for kicking and throwing. This pattern is similar to what was observed in locomotor skills, where the complexity of each task may have influenced the scores. The differences in performance could be explained by the varying levels of difficulty associated with each skill. According to Haywood & Getchell (2018), catching is rated lower due to its complexity, requiring hand-eye coordination, timing, and body adjustments, making it challenging for beginners like younger children. During the observation of the catching task, a few of the children began to progress as they were familiar with the task and also had the requirements of catching, which may add to the pattern of more practice and familiarity with the skill and developing it at a more gradual pace. Chen et al. (2017) explained that mastering motor skills depends on how well the learner engages with the task and environment. Effective motor skill development in children happens when they repeatedly engage in structured tasks aligned with their motor skill progression. Children gradually improve with practice because mastering a skill as a beginner takes time and consistent training to develop muscles slowly. Instant competence in a skill is rare, especially considering the ongoing development and injury risks at certain ages. For example, to master learning to dance or play an instrument, they would go through consistency of training and dedication, but they also started at a younger age, and they gradually learnt new skills as they developed their craft gradually. The interaction effect of time, group, and their combination was not significant, suggesting that the intervention did not significantly influence the improvement of ball skills. This result could possibly be due to the fact that the ball skills were not heavily used in the intervention; however, there are still some aspects of the ball skills displayed in the intervention, like catching. But, in the test, catching was completed in a static position, whereas during the intervention it was more

dynamic movement where the children were constantly moving. Kicking was involved in the intervention, however, it was usually done once, which is during the beginning of the game, and the ball size was different from the test. A soccer ball was used in the kicking task, which had a stronger texture compared to the ball used in the intervention, which was soft and small. Furthermore, throwing in the intervention was completed with the tennis ball being smaller and it was performed with one hand, whereas in the intervention you're using both hands to pass the ball. This suggests differences between tasks and interventions impacted skill improvement; aligning these skills in the intervention could enhance practice and children's ball skills. Boys outperformed girls in the ball skills task, indicating a significant gender difference in performance. Gromeir et al. (2017) stated a few studies that provide evidence of males having a better performance than females, and in this study what they found was that males between the ages of three and six outperformed girls in terms of throwing velocity and accuracy, and that males between the ages of five and six significantly outperformed girls in throwing accuracy, demonstrating the impact of age and gender on the performance of motor skills. There are biological differences between males and females that may lead to certain skills being performed more effectively by one gender. In the ball skills task, males outperformed females, but it's important to acknowledge the efforts of females in skill performance despite the differences in results.

4.2 Motor Assessment Battery for Children (MABC-2)

No significant main effect of time or group was observed for static and dynamic balance; however, both the intervention and control groups showed some improvements, especially in the intervention group from pre-test to follow-up. It has been highlighted that there was a lack of significant changes in static and dynamic balance, and this outcome could be due to factors such as lack of experience of the task, not concentrating on the task, environment factors, and so forth. In this test, we see a lack of significant changes, and the outcome of these results would be due to factors such as a lack of experience performing the task, a lack of concentration, or the effects of the surrounding environment. The activities that the children engage in may not involve much balancing. Participants' levels of competence in static balancing varied; some demonstrated significant progress while others remained consistently competent. Notably, the legend-only group exhibited unexpectedly high levels of competence in static balance. This outcome suggests that factors like natural developmental progress may have played a role in their performance, as children in this group showed better balance and

control in stationary positions compared to the other groups. Furthermore, cognitive processes in specific brain areas might enhance balancing abilities; for instance, while dynamic balance involves stability during movement, static balance involves maintaining stability in a stationary position. Since motor skills are influenced by cognitive processes, and dynamic tasks require greater mental processing ability (Divandari et al., 2023), it is possible that these cognitive aspects contributed to the legend-only group's performance. In contrast, while the other two groups also showed improvement, it was not as pronounced. This difference could be attributed to their inconsistent engagement in daily routines that support balance, such as sports like cricket, football, and hopscotch. Children who engage more regularly in these activities might have a natural advantage in balance tasks, influencing their performance across different groups. Findings suggest that static balance had a significant higher improvement whereas, dynamic balance did not significantly change, possibly due to participants age or particular procedures. This emphasises how important it is to take developmental variables and intervention types into account when evaluating balanced performance outcomes.

4.3 Cognitive Test

4.3.1 Head-Toes-Knees-Shoulders Test

The HTKS test revealed a pattern of significant improvement in scores over time, which suggests that the children executive functioning skills had developed positively. This may indicate that they were able to control their impulses, following multiple instructions, and enhance their working memory and attention over the duration of the testing. The results here have demonstrated the crucial importance of what executive functioning can do for the children development and be essential to their academic and social success. McClelland et al. (2017) concluded in their study that the HTKS results indicated as a practical tool that predicts children achievement over the transition to kindergarten. These study conclusions align with our interpretation of our finding, emphasising how important this skill can be to children development in regards to their cognitive functions, which can be essential for academic success and daily functioning. Additionally, the groups revealed no significant differences or interactions, which reflects a broader developmental pattern in cognitive skills during this age range. The pattern here reveals that executive functioning improves with age and individual differences, and therefore we can see the rate of development can differ significantly. Moreover, children at this age are still developing, and the results that show now may differ

when they are adolescents or at an older age. Segundo-Marcos et al. (2022) state that the development of executive functions began at a very early age and extended throughout the lifespan, with middle and late childhood being a critical period due to the changes associated with the development of neural networks involving the prefrontal context during this stage.

4.3.2 Corsi Block Test

There was significant improvement over time in the corsi block test. It indicates that the participants improved their performance as the task proceeded. This result could be due to various variables, such as practice. The age group of the participants that completed the task would have seen the task as complex at the beginning; however, once they practiced and understood the task, their performance improved. Practice can be essential to improving the performance, as stated in the findings of a study that demonstrated that even in young, healthy adults, corsi block tapping task performance can improve with practice, which suggests that visuospatial memory can improve with targeting training Schaefer et al. (2022). The improvement from post-test to follow-up showed no obvious changes in the results, and this is seen as a plateau effect in which most of the learning and improvement had occurred earlier in the testing procedure. This has indicated that the participants had performed as well as they could within the boundaries of the task or that the testing at a later point did not provide significant improvement. The forward task in the corsi block test showed higher scores compared to the backward task. Visually memorising things forward would be simple to remember, whereas remembering things backwards would be quite challenging, especially when the task requires the person to repeat those sequences backwards. This children are still developing, and therefore repeating those sequences backwards would have been complex. However, with more practice in mastering this skill, you may get better scores. In a previous study that had participants who were in the age range of 50–92, results showed that there were no difference between the forward and backward conditions of the corsi block tapping task and that it suggested that both conditions rely on the same cognitive process, which is the reason why there were no differences (Kessels et al., 2008). Comparing our findings with this previous study, we can observe that the process of developing the skill of spatial memory is still developing, and therefore, due to this skill still in the process of developing, the children will perform better once they mature. (Sorrentino et al., 2019) state that, “the memory load required might partly explain the difficulties in the exploration of more complex environments by

younger children who have not yet completed the maturation of cerebral areas involved in the processing of spatial memory". Furthermore, the findings from this study showed that there was no group effect, which indicates that no matter what conditions each group had, it did not impact the performance of the children in this task. Also, there was no interaction effect, which indicates that the improvement and task difficulty were consistent across each group. The gender effect was not observable, which indicates that both males and females had similar and consistent performance in that task.

4.3.3 Digit Recall Test

In this test, we also observe higher scores for the forward digit recall task, which is similar to the results we saw in the corsi block test with the forward task. This outcome suggest that recalling a sequence of two or more numbers in a forward direction is simple compared to backwards. While longer sequences can be complex to recall backwards, shorter sequence would remain possibly simple to perform. Complexity process explains the difference between the forward and backward recall task, which shows that forward recall is found greater than backward recall due to only needing "passive storage of item whereas backward would need the passive storage of items in addition to a transformation of the items in the store in order to recall the items in reversed order of entry"(Rosen & Engle, 1997). Additionally, working memory played an essential part in this task by temporarily holding smaller amounts of information, such as the sequence of digits. The forward recall is easier due to the information that is still in working memory. Whereas the backward recall may have been more challenging if the information had been moved to long-term memory or if other factors, such as a longer sequence or stress, impacted their ability to retrieve and manipulate their stored information.

Furthermore, the task identified no significant effects of time, which indicates that the performance of children did not change over the duration of the testing. The outcome of this result could possibly be due to the complexity of this task, minimal practice, and no daily activities that require the engagement of this task, or if the duration of the testing would have been longer, then improvements could be evident.(Guo et al., 2018) study found that after six weeks of instrumental music training, the experiment group showed significant improvements in the digit span test (backwards task) that measured working memory. The outcome in this study does not align with what we found; however, we can identify that there was improvement within that short-term time frame, but if the time frame were extended, we could plausibly get

a bigger improvement. Moreover, playing and training an instrument is quite complex, and it does take a lot of practice and learning to master the skill of playing an instrument, which may have impacted the scores in the digit span task as this test would require your working memory.

4.4 Social Skills

The social skills test identified significant improvements over time for both the intervention and control groups; however, with the story- only control group showed no significant changes. The results clearly show that scores improved from the pre-test to the post-test for both the intervention and control groups, while the legend-only group did not show any changes in scores. Moreover, although both the intervention and control groups made progress, the control group demonstrated superior social skills. This indicates that the intervention improved the social skills of those children. However, other factors, such as extracurricular activities like sports outside of school, playing in the playgroup during recess, and family activities, may have also influenced the improvement in social skills across different groups. This is consistent with the teachers' feedback and observations. One teacher remarked, "I noticed a positive change in how the children interacted with each other." However, a concern was raised about the control group's early advancement in social skills. One teacher pointed out, "The control group seemed to have a head start in social skills," which likely influenced our results. The findings underscore the potential of structured activities to enhance social competence in children. Structured games and activities can help children improve their social and life skills (Chatzipanteli & Adamakis, 2022). The varying results among the groups could be attributed to the interactions and involvement of children. The findings indicate how important interaction in any activity can be valuable towards social skills, like playing games, and for the legend-only group, interaction may have been absent, which may have impacted their result. Furthermore, in their daily routines at school, home, or in the community, limited engagement with others may have affected their social skills results. While every child can engage and interact with their peers, listening to a story can provide some interaction, but it may not be as effective as playing a game. This aligns with the understanding that social connection is essential to learning because it facilitates understanding, helps organise ideas, and points out obvious mistakes (Okita, 2012). Overall, the findings have highlighted how effective the intervention can be in developing children’s social skills. Additionally, emphasising the importance of interacting with their peers can also help with their social skill development.

In summary, the findings of this study have highlighted that playing Ki-o-Rahi can enhance children's physical, cognitive, and social skills. Starting from young age, participating in Ki-o-Rahi could help children develop their skills and build a solid foundation. This enables them to engage in physical activities, solve problems, strategies to overcome challenges in games, and communicate effectively with teammates and others around them. In conclusion, Ki-o-Rahi is beneficial as it nurtures children's physical, cognitive, and social skills holistically and in combination rather than in isolation.

Chapter Five: Limitation

This study had a few limitations, including the shorter timeframe of the intervention, which may have impacted the generalisation of the findings. Sample size was a limitation as it was small and that each subgroup was not equally numbered, which may have affected the findings. Also, this smaller sample may have limited the ability to determine significant differences or effects of the groups. Additionally, the timeframe of data collection is a limitation, as the duration of the intervention is short, and that it is not a sufficient time to produce significant changes or log-term effects. Moreover, the duration allocation of the post-test might also not be sufficient to examine consistent effects or identify whether the changes from the intervention are lasting. The lack of diversity in participant ethnicities was limited, and it may have impacted the results in varies way, like limitation to generalisation of results, bias in findings may lead to some culture details overlooked or accidentally reinforce steroytpes; certain ethnic groups may have underrepresentation of specific needs that are not addressed if they are underrepresented within the study, and so forth.

Chapter Six: Conclusion

The study aimed to examine whether Ki-o-Rahi can be implemented to develop fundamental movement skills (FMS) in Aotearoa New Zealand children and contribute to effective cognitive and social development. It was hypothesised that the children in the intervention group would show greater improvements in their physical, cognitive, and social skills compared to those in the control groups. Findings demonstrated that the intervention and control group had significant improvements in the motor and social developments; however, cognitive

development showed more gradual progress and did not display a significant benefit over the control groups. This has indicated that Ki-o-Rahi was an effective intervention to enhance fundamental movement skills (FMS) and social skills in Aotearoa New Zealand children; furthermore, the intervention group showed more effective improvement compared to the control groups. For future research, it is recommended that the timeframe of the study be longer so that the results that are found are effective and sufficient for a long-term effect. Additionally, applying this study to Pacific or Māori children to observe if there are any changes or similarities in results

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Appendix A

Ethics approved application

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THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

6 March 2023

Rich Masters
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Liis Uiga
George Barrett
Rawi Nuku
Wiliame Daveta
Collaborating Teachers from participating primary schools (*to be confirmed*)

Re: HECS Ethics Approval of Application HREC(HECS)2023#04 "Preparing our tamariki for successful learning: A values-based approach to the development of movement competence by young children"

Dear Rich and So Hyun:

Thank you for submitting your amended application HREC(HECS)2023#04 for ethical approval.

We are pleased to provide formal approval for your project, including the following activities:

- Recruit approximately 90 new entrant/Year 1 children aged 5-6 years through four primary schools in the Waikato region for an intervention study that compares modified Ki-o-Rahi with typical fundamental movement skills training.
- Children will play modified Ki-o-Rahi during their school's physical education lessons over one or two school terms or participate in their regular physical education lesson.
- Children will be assessed for their gross motor skills and cognitive functions at three time points (pre-study, post-test, and follow-up test). Additionally, parents will be invited to complete surveys that include background information and activities of their child (approximately 20 minutes to complete).
- Written formal consent will be sought from parents / caregivers as children will be 5-6 years of age; however, additional verbal consent will be gained from individual children.

Please contact the committee by email (hecs-ethics@waikato.ac.nz) if you wish to make changes to your project as it unfolds, quoting your application number with your future correspondence. Any minor changes or additions to the approved research activities can be handled outside the monthly application cycle.

We wish you all the best with your research.

Kind regards,

Brett Langley, PhD
Chairperson
HECS Human Ethics Committee
University of Waikato

Appendix B

Social Skills Questionnaire

Early Childhood Social Relationship with Peers (Teacher-Proxy)

Classroom: _____ Pre / Post / Follow-up (circle one)

Teacher: _____ Date: _____

Child's full name: _____	**Never 1**	**Rarely 2**	**Sometimes 3**	**Often 4**	**Almost always 5**
1. _____ always volunteers to help when s/he sees someone in need……	☐	☐	☐	☐	☒
2. _____ is considerate of his/her surroundings, nice to others, and kind……	☐	☐	☐	☐	☐
3. _____ shares with other children (e.g., toys/food etc) ……	☐	☐	☐	☐	☐
4. _____ respectful of teachers……..……	☐	☐	☐	☐	☐
5. _____ tends to be the leader in group activities with other children……..……	☐	☐	☐	☐	☐
6. Other children see _____ as a leader and trust him/her as a leader……	☐	☐	☐	☐	☐
7. _____ cooperates well with other children in his/her group……	☐	☐	☐	☐	☐
8. _____ is self-centred, does not recognise other children's interests……	☐	☐	☐	☐	☐
9. _____ easily adjusts to new situations……..……	☐	☐	☐	☐	☐
10. _____ is able to suggest different solutions to a problem……	☐	☐	☐	☐	☐
11. _____ seeks to resolve conflicts peacefully……..……	☐	☐	☐	☐	☐
12. _____ easily gets into tantrums……	☐	☐	☐	☐	☐
13. _____ forgives quickly and does not seek revenge on children who hurt him/her……..	☐	☐	☐	☐	☐
14. _____ initiates or proposes games to other children……	☐	☐	☐	☐	☐
15. _____ engages in physical activity/active play……	☐	☐	☐	☐	☐

Appendix C

Ki-O-Rahi Field Setup

The examiners set up the Ki-o-Rahi field on a covered basketball court measuring 27.9 m x 11.8 m before recapping the story to the participant. The Tupu was set up in the centre of the court. From the bottom of the barrel, we measured out a diameter of 70 cm, and we taped around a yellow rope for the Te Wairua. From the Te Wairua, we measured out a diameter of 3 metres, and we set up a white circle for the Pawero. A blue rope was taped all the way around the Te Roto, which was measured out from the Pawero with a diameter of 7.2 metres. For the Te Ara, two blue ropes were taped through the Te Roto, and for the Te Ao, the examiner measured 20.7m. Seven stars were placed around the Te Ao and measured at various distances: from star 1 to star 2, at a distance of 5.60 metres, from star 2 to star 3, at a distance of 3.20 metres, from star 3 to star 4, at a distance of 5.80 metres, from star 4 to star 5, at a distance of 2.60 metres, from star 5 to star 6, at a distance of 4.40 metres, from star 6 to star 7, at a distance of 2.50 metres, and from star 7 to star 1, at a distance of 8.70metres. The story was recapped, and the participants were provided of the main responsibilities of the two teams they would be placed in. After finishing the recap of the story, we led the participants outside to play the game Ki-O-Rahi.