Associations between Fundamental Movement Skills, Gymnastics and Movement Specific Reinvestment

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Abstract

The propensity for conscious monitoring and control of movement (i.e. movement specific reinvestment) influences the acquisition of movement skills. Fundamental movement skills (FMS) are basic motor skills that children must learn and accomplish as they are a key component for participation in sport and physical activity. Recreational gymnastic programmes are saturated with activities associated with the development of FMS, so this study aimed to examine the relationship between conscious control of movements, as defined by the theory of reinvestment (Masters, 1992; Masters & Maxwell, 2008; Masters, Polman, & Hammond, 1993), fundamental movement skills and gymnastic skills in children. The purpose of this study is to understand the role of movement specific reinvestment (MSR) and gymnastics experience in developing FMS and gymnastic-specific skills in children.

Two hundred and two novice child gymnasts (*Mean age* = 8.02 ± 2.35 years; range = 5-15 years) were asked to complete a modified version of the Movement Specific Reinvestment Scale for Children (MSRS-CC) (Ling, Maxwell, Masters, McManus, & Polman, 2016; Masters, Eves, & Maxwell, 2005; Masters & Maxwell, 2008) in week 1 and week 9 of a gymnastic course to measure their propensity to consciously monitor and control their movements. Children repeated the modified MSRS-CC again in week 9 to investigate whether the propensity for movement specific reinvestment changed. The children were assessed on two basic gymnastic skills in week 1 and week 9 to investigate whether the propensity for movement specific reinvestment accounts for improvement of gymnastic skill acquisition. Children were also asked to perform four FMS from the two subcategories of object control and locomotor skills in week 1 of the gymnastic course. When registering to participate, parents indicated the level of their child's previous gymnastic experience by answering questions to investigate if a child's gymnastic experience and propensity for movement specific reinvestment is associated with developmental level of FMS.

The results showed that out of the four measured FMS (horizontal jump, slide, stationary dribble, and underhand throw) only horizontal jump was significantly

correlated with gymnastics experience, with more experience associated with better performance. The results further showed that lower scores on the Movement Specific Reinvestment Scale were associated with improvements in the gymnastic skill of the forward roll. When examining the individual contribution of CMP and MS-C to the development of the forward roll, only CMP was found to significantly account for the improvements, with higher scores on CMP associated with less improvement. Results also indicated that both CMP and MS-C increased significantly from week 1 to week 9, suggesting that post-training children tended to consciously engage in movement processing more than pre-training. Training instruction appears to impact reinvestment propensity. To accelerate children's development of FMS, children need to reduce reinvestment, and this could be achieved with implicit instructional methods that avoid explicit directions to monitor movement and appearance.

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Tables

Abbreviations

MSR – Movement specific reinvestment

MSRS – Movement specific reinvestment scale

CMP – Conscious motor processing

MS-C – Movement self-consciousness

FMS – Fundamental movement skills

OB – Object control

LM – Locomotor

TGMD-3 – Test of gross motor development – third edition

GST – Gymnastic skill test

Thesis Outline

Chapter organisation

Chapter 1 - Introduction

Introduces the problem statement and summarises the literature on movement specific reinvest, fundamental movement skills and child gymnastics. Including definitions, assessments, previous research findings and analysis of methods used by researchers. Also presents the research objectives.

Chapter 2 - Methodology

Presents the research framework of the method.

Chapter 3 – Results

Investigates the association between movement specific reinvestment, fundamental movement skills and child gymnastics and draws on key findings through tables.

Chapter 4 – Discussion and conclusion

Summarises the findings of the research with limitations and recommendations for future research.

Chapter 1
Introduction

1.1 Fundamental Movement Skills

Fundamental movement skills (FMS) are defined as core components of physical development or "building blocks" of more advanced, complex movements required to participate in sports, games, or other contexts specific to physical activity across childhood and adulthood (Bardid, Lenoir, Huyben, De Martelaer, Seghars, Goodway, & Deconinck 2017; Hardy, Barnett, Espinel, & Okely, 2013; Logan, Ross, Chee, Stodden, & Robinson, 2018; Lubans, Morgan, Cliff, Barnett, & Okely, 2010). Skills that compose FMS include three sub-categories: object control skills, locomotor skills and stability (balance) skills (Gallahue, Ozmun, & Goodway, 2012; Rudd, Barnett, Butson, Farrow, Berry & Polman, 2015). Object control skills involve manipulating an object in action situations and commonly consist of over and under hand throwing, catching, dribbling, kicking, striking, and rolling of a ball. Locomotor skills involve the human body being propelled from one place to another and consist of walking, running, jumping, hopping, leaping, galloping, skipping and sliding skills. Stability (balance) skills involve the ability to adjust the body accurately and rapidly with appropriate and compensating movements (Rudd, et al., 2015) and consist of dodging, body rolling, bending, stick balancing, one foot balancing, stretch, swinging, turning and twisting skills (Gallahue, et al., 2012). FMS are basic motor skills that children must learn and accomplish as they are a key component for participation in sport and physical activity; therefore, mastering FMS as a set of skills during childhood is paramount.

FMS are prerequisites for performing sport specific skills (Barnett, 2016). As children develop FMS and become proficient in the fundamental stage of movements they can continue to expand their sporting skills. Children need to develop FMS if they are going to reach excellence in sport (Arede, Esteves, Ferreira, Sampaio, & Leite, 2019). For example, dribbling a ball is a movement skill required to develop excellence in basketball. Running, throwing and catching a ball, and dodging are movement patterns essential for rugby. Balancing, swinging, twisting are movement patterns required in gymnastics. To participate successfully in many structured and non-structured games, recreational activities and sports (e.g., rugby, riding a bike, tag, hopscotch, tennis), a high level of competence in FMS is required (Wolstencroft, 2002). Indeed, research has shown that children who have higher levels of FMS acquire sport skills with more ease than children who have a lower level of FMS (Arede, et al., 2019).

Research suggests that the FMS sub category of object control skills is significantly associated with moderate to vigorous physical activity during school lunch time and recess breaks (Cohen, Morgan, Plotnikoff, Callister, & Lubans, 2014). Children who have higher levels of FMS utilise free time at school by playing sports and games, thus increasing their physical activity levels. Children with low levels of FMS spend more time watching others and less time playing and engaging in physical activity. Additionally, improving FMS proficiency in children has been shown to heighten weekend activity (Capio, Sit, Eguia, Abernethy, & Masters, 2015). Evidence supports the mastery of FMS in children to promote physical activity (Stodden, et al. 2008; Capio, et al., 2015). Children who have mastered FMS should have higher levels of physical activity, which can lead to lifelong participation in sport or physical activity. An understanding of children's levels of FMS and how to improve them is therefore relevant.

It has been suggested that FMS do not develop naturally or automatically over time, but rather development of FMS only occurs with quality teaching and regular practice (Wolstencroft, 2002). Research has shown that children who were directed by specialists to learn FMS (i.e., FMS specialist intervention programmes for children or instructional strategies from expert teachers or coaches) displayed a greater increase in FMS than children who engaged in only free play (Robinson, et al., 2015; Hastie, Valentini, Rudisill, & Chiviacowsky, 2018). Furthermore, these findings suggest that instructions are related to and predictive of motor skill acquisition for FMS. Young children need directed instruction, feedback and practice if they are to develop a mature form of FMS competence (Bardid, et al., 2017; Lubans, Morgan, Cliff, Barnett, & Okley, 2010). All children benefit from FMS instruction, but research indicates that children with lower levels of FMS who participate in FMS intervention programmes demonstrate higher gains than children with higher levels of FMS (Bardid, et al., 2017). Children with lower levels of FMS can accelerate their improvement at a greater rate if participating in structured learning of FMS compared to children with high levels of FMS.

1.1.1 FMS and physical activity, health and cognitive ability

It is well established that mastering fundamental movement skills (FMS) during childhood will contribute to a child's physical, cognitive and social development and increase the probability of lifelong commitment to physical activity and sport (Bardid, et al., 2017; Capio, Mak, Tse, & Masters, 2018; Coelho, 2010; Field & Temple, 2017; Hardy, et al., 2013; Lloyd, et al., 2016; Lubans, et al., 2010; Robinson, et al., 2015; Stodden, & Goodway, 2007). However, FMS go beyond sport skill development as increasing numbers of researchers in fields of health, medicine, sport and physical activity are using FMS to battle current health problems of heart disease, diabetes and obesity (Stodden, et al., 2008). In 2014, approximately 31% of New Zealand children between 2 - 14 years old were classified as either overweight (21%) or obese (10%) (Ministry of Health, 2014). A positive relationship exists between competence in FMS and physical activity across childhood (Robinson, et al., 2015; Capio, et al., 2015). It has been suggested that children with greater FMS are more active, which fights the problem of obesity (Stodden, et al., 2008). Luban, et al. (2010) performed a systematic review to identify health benefits associated with FMS competency in children and adolescents. Twenty-one articles assessed eight potential health benefits, including weight status, physical activity and sedentary behaviour. The results of this review confirm a relationship between FMS competency and physical activity in children and adolescents. Participating in physical activity reduces the risk of heart disease, diabetes, and obesity and promotes healthy bone development (Field, & Temple, 2017). Furthermore, children who participate in physical activity consistently demonstrate reduced symptoms of anxiety and depression (Clarke, Barnes, Holton, Summers, 2016).

Proficiency in FMS is also associated with academic outcomes (Magistro, et al., 2018; Haapala, 2013; Piek, Dawson, Smith, & Gasson, 2008). Associations of FMS with academic performance include measures of grade point averages, estimated academic performance by the school teacher and reading skills. Children with greater perceptual motor abilities have higher grade point averages (Haapala, 2013). Furthermore, evidence shows that FMS predict item memory (Piek, Baynam, & Barrett, 2006). However, Ericsson (2008) showed a weak positive association between motor skill training and improved academic performance and reading among school aged children.

It has also been shown that children's social development can be affected by their levels of FMS (Clarke, et al., 2016). For example, children with low levels of FMS will more commonly experience emotional difficulties, such as depression and anxiety (Piek, et al., 2006). Generally, children with low levels of FMS tend to avoid situations that will display their lack of ability in front of others, thus missing out on social opportunities to develop their physical activity (Clarke, et al., 2016). On the other hand, children who choose to participate in physical activity demonstrate reduced levels of anxiety and depression, and improved self-esteem and confidence (Field, & Temple, 2017).

Evidence supports the view that physical, cognitive and social development are associated with levels of FMS in children and can impact children's lives positively or negatively depending on their level of proficiency. Low levels of FMS can lead to anxiety, depression, sedentary behaviour and obesity, all of which are problems faced by New Zealand families. Youth suicide in New Zealand has reached its highest-ever level, with 685 people dying in the year 2019 up to June 30th **(**Stuff limited, 2019, para.1). Research indicates that FMS can affect a child's everyday functioning and life, from their socially driven activities during school playtime (Cohen, et al., 2014) to their extra-curricular sporting pursuits (Arede, et al., 2019) and weekend play (Capio, et al., 2015). Children who lack FMS are at risk of exclusion from structured and non-structured play experiences with friends and a lifetime of inactivity (Field, & Temple, 2017).

1.1.2 Measuring FMS

Most FMS research has focused on children's competene in locomotor and object control skills (Bardid, et al., 2017; Hardy, et al., 2013; Logan, Robinson, Rudisill, Wadsworth, & Morera, 2012). The Test of Gross Motor Development (Ulrich, 2000) is a process orientated assessment construct predominantly used by most researchers of FMS for primary school aged children. Logan, et al. (2018) performed a systematic review of three FMS areas: the use of the term FMS, the quality of the definition for FMS and the use of process and product-orientated assessments to measure FMS. One hundred and ninety-eight articles were screened, of which one hundred and twenty four met the inclusion criteria. Out of the seventy-nine percent of studies that administered process oriented measures to assess FMS, sixty-four percent administered the test of Gross Motor Development (Logan, et al., 2018).

Test of Gross Motor Development, second edition (TGMD-2) (Ulrich, 2000) is a widely used instrument for studies involving children from the age of three to ten years (e.g., Capio, et al., 2018a; Ling, Maxwell, Masters, McManus, & Polman, 2016). TGMD-2 is a validated, process-orientated assessment with high internal consistency ($\alpha > 0.80$) and good content validity (Ulrich, 2000). Logan, et al., (2012) compared two FMS tests of TGMD-2 with Movement Assessment Battery (MABC-2) and suggested that that the TGMD-2 may be a better assessment of the relationship between motor competence and physical activity.

The TGMD-2 measures the performance of twelve FMS within two distinct subscales of locomotor skills (run, leap, gallop, hop, horizontal jump, slide) and object control skills (striking a stationary ball, stationary dribble, catch, kick, overhead throw and underhand roll). Each skill is evaluated by three to five performance criteria. Children are given one practice with two formal trials. The FMS are assessed by an examiner with training in administering and interpreting test results and with knowledge about motor development.

The most current and modified third edition of TGMD is a process-orientated test of gross motor skills in young children, aged 3-10 years (TGMD-3) (Ulrich, 2000).

TGMD-3 has only recently been released and established as a valid instrument and reliable tool to evaluate, compare and assess gross motor skills in children who are typically developing and also children with mental and behavioural disorders. The difference in the new third edition in comparison to edition two of TGMD includes the total number of skills; thirteen instead of twelve. The underhand roll (object control skill) and leap (locomotor skill) have been taken out of the test and replaced with three new skills. One new loco motor skills (skip) and two new object control skills (underhand throw and one-handed fore-hand strike). Magistro, et al. (2018) assessed the validity of TGMD-3 score, confirming its factorial structure across typically developed children and children with mental and behavioural disorders. Furthermore, item response theory analysis using a graded response model showed that this instrument can discriminate efficiently between children with low and high levels of gross motor skills (Magistro, et al., 2018).

FMS sub categories of locomotor skills and object control skills have been extensively researched in children's levels of FMS and commonly used within the literature but the FMS sub category of stability (balance) skills are less researched, if at all measured. Stability (balance) is present in definitions but lacking in assessment measures (Clarke, et al., 2016; Lubans, et al., 2010). Clarke, et al. (2016) suggests "…as identified by Rudd, et al. (2015), although stability skills are recognised as key to fundamental movement, they are scarcely examined, with predominantly locomotion and object control being assessed (Lubans, et al., 2010). Therefore it would be recommended that further research analyse stability competence." (p. 271). Including stability measurements would allow more accurate assessment of performance quality.

Stability and balance, terms used interchangeably, are skills that can be defined as the ability to sense a shift in the relationship of the body parts that alter one's balance, as well as the ability to adjust rapidly and accurately to these changes with the appropriate compensating movements (Rudd, et al., 2015). Coelho (2010) indicates that stability is an important component of motor fitness. It has a direct relationship to improved health and fitness, especially as people age. "Good balance can help reduce falls, a leading cause of injury in older people. Effective balance can enhance children's ability to participate in sports and contribute to increased body awareness" (Coelho, 2010, p.17). In other research involving children with typical development, it has been suggested that holistic measurement of FMS should include stability skills, which have been found to make up a discrete construct that contributes to FMS competence (Capio, et al., 2018a; Rudd, et al., 2015).

Mastering of the stability skill has the potential to help reduce falls and injuries in children. There is a lack of measurement of the FMS sub category stability (balance) skill within the literature due to the absence of assessment measures. Stability is a commonly performed FMS skill in the sport of gymnastics. Thus, gymnastics measurement of this skill would provide a more inclusive measure of FMS. Coelho (2010) supports the view that rolling teaches safe fall techniques and Rudd, et al. (2015) found that out of the three postural control tasks, one of the tasks was a log roll. The log roll involves the participant rolling sideways whilst maintaining a straight body shape. The rolling task had good face validity and content validity. Rolling activities demonstrated good predictive validity with gymnasts scoring significantly better than children without gymnastic training.

1.2 Gymnastics and Fundamental Movement Skills

1.2.1 Gymnastic skills and the importance of examining in the context of FMS

FMS are common activities undertaken in recreational gymnastic programmes. A substantial part of the skills in gymnastics is learning how to fall safely, which is a fundamental movement challenge. "We need to prepare students for the many movement-related challenges they will encounter throughout their lifespans" (Thompson, & Robinson, 2016, p.1). Learning how to fall safely includes, activities of landing, rolling, and stability (balance).

Gymnastics is saturated with activities related to stability skills. These activities can include using the beam apparatus or balancing on various body parts. Other FMS skills in gymnastics include locomotor skills, which are prolific throughout gymnastics. Locomotor skills in gymnastics include the vault, tumbling, beam, bars and rings. FMS object control (ball) skills are less predominant in recreational gymnastics unless an element of rhythmic gymnastics is present, such as throwing, rolling and catching of ribbons, balls and hoops. Recreational gymnastic activities incorporate all three FMS subcategories of locomotor skills, object control skills and stability (balance) skills. Gymnastic activities use FMS making the movements gradually more advanced and complex as a child develops their FMS; for example, balancing on a beam whilst jumping combines stability skills with locomotor skills.

1.2.2 Evidence of an association between gymnastics and FMS

Previous research has found evidence of a strong association between fundamental movement skills and gymnastics, supporting the view that gymnastics programmes can accelerate learning of fundamental movement skills in children (Karachle, Dania, & Venetsanou, 2017; Rudd, Barnett, Farrow, Berry, Borkoles, & Polman, 2017a; Field, & Temple, 2017). There is a positive transfer of skills between gymnastics and FMS (Culjak, Kalinski, Kezic, & Miletic, 2014) and frequent practice of gymnastic skills improves FMS (Rudd, Barnett, Farrow, Berry, Borkoles, & Polan, 2017b). For example, Field, and Temple, (2017) demonstrated that of fifty-five recreation and leisure activities in which children participated during extra-curricular time, gymnastics was the only activity positively correlated with girls' motor skills, specifically their locomotor skills. Similarly, children with higher levels of FMS learnt gymnastic skills with more ease (Culjak, et al., 2014). A lack of gymnastics training may be a contributing factor for children failing to develop more complex skills (Rudd, et al., 2017a). Specifically, Fallah, Nourbakhsh, and Bagherly (2015) investigated the improvements of locomotor skills after eight weeks of gymnastic training in 40 five to six year old girls. The authors showed significant improvement of balance and locomotor skills among children who participated in the recreational gymnastics compared to children who did not participate in gymnastics.

Researchers are unanimous about the relationship between gymnastics and locomotor skills; however, opinions differ with respect to the relationship between gymnastics and object control skills. This is due to views that gymnastics does not commonly involve practice of object control skill activities, therefore little improvement is to be expected. However, gymnasts need to show careful co-ordination of hand placements when catching the bar apparatus or move carefully using both hands on the beam apparatus, so potentially these gymnastic activities could improve object control skills without the use of a ball. Rudd, et al. (2017a) showed that although gymnastics programme did not target improving object control skills, accelerated development with greater improvements were still observed compared to a control group of participants who did not participate in a gymnastics programme. This improvement may contribute to superior development of balance and greater perceptual capacity (Rudd, et al., 2017a). In another study by Rudd, et al. (2017b), the impact of gymnastics on children's FMS in primary schools was investigated. The authors found that improvements during the lower primary years (year 2 to year 4 school age), were mainly due to improvements in object control skills. These results suggest a possible transfer between gymnastics and the development of more complex skills. On the other hand, Culjaks, et al. (2014) investigated FMS and gymnastic skill improvement in 75 children over a 18-week training program. They found significant progress in gymnastic skills performance, which, however, was not associated with development of object control skills. Field and Temple (2017) similarly showed that performance of locomotor skills but not object control skills was associated with gymnastics experience.

1.2.3 Gymnastics and self-focused attention

Simone Biles is the most decorated gymnast in the world and current Olympic artistic gymnastic champion. In a quote on competing under pressure, she states "Most people would focus on concentrating more, and I can't do that. It almost makes me overthink a lot of my things. I have to focus on not thinking" (Biles, 2018). Gymnastics is a sport that could be viewed as requiring high cognitive demands. A greater understanding of the cognitive demands of gymnastic skills is relevant, especially in relation to the early stages of learning gymnastics.

Sports can be defined as open or closed. Gymnastics is a closed skill sport as categorised by Poulton (1957). The cognitive demands on open and closed skill performers may be different as noted by Allard, et al. (1985). A novice child gymnast performs in an unchanging environment so they are expected to internally monitor more than open skill performers who have environments to externally monitor.

Novice gymnastics is yet to be tested or researched with focus of attention. Internal monitoring is more likely to occur due to the success of the movement dependant on the appearance of their body whilst performing the skill. For higher scores in gradings or competitions, gymnasts have to make their performance look aesthetically pleasing to the judge or scorer. Gymnastics is a sport scored or judged with subjectivity, unlike sports that gain results through best finishing time, that is first across the line or highest amount of goals scored. Gymnasts are scored for their body shape during their movements. Gymnastics, therefore, is a sport in which children need to be consciously aware of what they look like. Furthermore, gymnastic skills are difficult for children to acquire as they are very complex, fast moving and physically demanding, requiring careful coordination of the motor apparatus. Conscious engagement in the process of moving may be a factor that influences the way in which FMS develop during gymnastics.

At school, sports is often taught in a competitive situation of wins and losses. Gymnastics, however, in school sport situations is different to other school sports as it is generally taught without additional pressure or competitiveness of team wins or losses and could be viewed as a less threatening environment (Rudd, et al., 2017b). Children in gymnastics would be expected to concentrate on their appearance rather than winning. The less competitive situation and the closed sport environment may contribute to child gymnastics influencing their thoughts and performance. Gymnastics therefore is a contextually relevant platform for examination of the relationship between FMS and conscious monitoring and control of movement (i.e. movement specific reinvestment).

1.3 Movement Specific Reinvestment

1.3.1 Definition

The theory of reinvestment (Masters, 1992; Masters et al., 1993; see Masters & Maxwell, 2008, for a review) seeks to explain the role of conscious processes in acquisition and control of movements and is relevant for understanding the ways in which performers (e.g., gymnasts) develop movement skills. Movement specific reinvestment has been defined as the "manipulation of conscious, explicit, rule-based knowledge by working memory, to control mechanics of ones' movement during motor output" (Masters, & Maxwell, 2008, p.161). In other words, movement specific reinvestment refers to the process of thinking about and controlling body movements during motor performance. Masters, et al. (1993) further argued that the propensity to engage in conscious movement processing varies from person to person and from one situation to the next.

1.3.2 Measuring individual propensity for movement specific reinvestment

A person's propensity to consciously monitor and control movements can be assessed using the Movement Specific Reinvestment Scale (MSRS; Masters, Eves, & Maxwell, 2005). The MSRS has ten items, five items in each of two subscales: conscious motor processing (CMP) and movement self-consciousness (MS-C). CMP reflects an individual's tendency to consciously control their movements, with questions such as "I am aware of the way my body works when I am carrying out a movement" and M-SC reflects an individual's tendency to reflect on their 'style' of movement, with questions such as "I am concerned about my style of moving". According to the theory of reinvestment, a person who has a high propensity to reinvest would be more concerned about what others think of their movements for the subcategory of MS-C. For the subcategory of CMP, a person with a high propensity would think more about technical rules during their skill performance. The MSRS is a validated and reliable psychometric measure of individual differences in the propensity for conscious monitoring and control of movements among adults (Masters, et al., 2005) and children (Ling, et al., 2016).

1.3.3 Evidence for movement specific reinvestment in demanding contexts

The theory of reinvestment has been influential in fields of clinical research, surgical practice, health-related disciplines and within the sporting context. In clinical research with older adults during walking, Wong, Masters, Maxwell, and Abernethy, (2008, 2009) showed that older adults who repeatedly fall have a higher propensity to consciously monitor and control their movements than older adults who have not fallen. Additionally, in research on young and older adults, the results indicated that higher scores on the MSRS were associated with larger sway amplitude and a more constrained (less complex) mode of balancing by young adults only (Uiga, Capio, Ryu, Wilson, & Masters, 2018). Additionally, people with Parkinson's disease have been found to have a higher propensity for movement specific reinvestment and over time the propensity for CMP increased (Masters, Hall, MacMahon, & Eves, 2007).

In the field of surgical practice, movement specific reinvestment has been shown to be associated with training of undergraduate medical students on a fundamental laparoscopic skill (Malhotra, Poolton, Wilson, Leung, Zhu, Fan, & Masters, 2015b). The research investigated individual differences in propensity for MS-C and CMP in practice of a fundamental laparoscopic skill and in laparoscopic performance during objective structured clinical examinations (OSCE). Results indicated that a higher propensity for conscious motor processing predicted faster rates of learning of a fundamental laparoscopic skill (Malhotra, et al., 2015b). Earlier research (Malhotra, et al., 2014) also identified personality factors that account for individual differences in surgical training and performance. Results indicated the higher propensity for MS-C was associated with slower performance times on learnt laparoscopic tasks. These findings suggest that CMP is related to faster learning but MS-C with slower performance times. A possible explanation is offered in that surgical trainees learn skills under direct supervision of senior surgeons, so pressure to look and behave like a surgeon may provoke debilitative MS-C behaviour (Malhotra, et al., 2014, p. 802).

The MSRS has been also used in health-related disciplines. For instance, Capio, Uiga, Malhotra, Eguia, and Masters (2018b) showed that physiotherapists scored higher than other professionals on both of the two movement specific reinvestment sub-scales. Results also showed that physiotherapists with fewer years of practice (i.e., beginner and novice physiotherapists), tended to have higher movement self-consciousness scores. This is similar to the findings in surgical performance (Malhotra, et al., 2014), in that high MS-C scores lead to slower performance. Beginner physiotherapists are also found to have high MS-C scores. One would expect beginners to be slower, and professionals such as physiotherapists, who study movement for a living (beginner or expert level), to have a higher propensity for MS-C than other professions that do not study movement (Capio, Uiga, Malhotra, Eguia, & Masters, 2018b).

Evidence supports a role of movement specific reinvestment in motor performance in adults during sport (Buszard et al., 2013; Chell, Graydon, Crowleys, & Child, 2003; Jackson, Kinrade, Hicks, & Wills, 2013; Masters, & Maxwell, 2008). Multiple studies in a sporting context have shown that under psychological pressure adults who consciously process their movements are more likely to experience failure or disrupted performance. Sports that have been researched include tennis (Buszard, et al., 2013), golf putting (Maxwell, Masters, & Polman, 2006), trampolining (Hardy, Mullen, & Martin, 2001), hockey and netball (Jackson, et al., 2013) and soccer (Chell, et al., 2003). These researchers support movement specific reinvestment and are unanimous in that adults who score high on MSRS perform poorly in high pressure conditions whilst adults who score low on the MSRS can maintain performance under pressure conditions.

1.3.4 Evidence for movement specific reinvestment during early learning

Malhotra, et al. (2015a) directly examined reinvestment during early stages of learning and showed that movement self-consciousness and conscious motor processing may benefit performance during learning a golf putting task. Findings suggest that early in practice when skill execution is difficult, MS-C and CMP tend to positively influence performance (Malhotra, et al., 2015a). Buszard, Farrow, Zhu, and Masters, (2013) examined the association between movement specific reinvestment and working memory capacity in children and adults. In study 1, significant associations were found between verbal working memory and movement specific reinvestment in children, indicating that children with high verbal working memory capacity tend to display a high propensity for movement specific reinvestment. In study 2, adults performed a tennis hitting task as it is thought to be a complex skill for early learners. The adults with high working memory capacity were expected to be more affected by depletion of their working memory under pressure. Results showed that hitting performance was significantly higher in the pressured environment. Verbal working memory was negatively correlated with change in hitting performance under pressure suggesting that improvement in performance under pressure were associated with low verbal memory capacity.

Indirect evidence of reinvestment in early learners has been provided by Gray (2004) and Beilock (2002). In a study of novice baseballers, Gray (2004) found that, in contrast to the expert players, introducing a non-skill focused auditory tone that distracted from consciously processing movements, resulted in an increase in swing error. The results of this study suggest that novice baseball players do not have the available attention resources to pick up the sources of information in the non-skill focused tasks. Another study was performed on expert softball players, comparing top of the league players with bottom of the league players (Allard, Burnett, & Charness, 1985). The players were given tasks that would interfere with their hitting ability, by recalling ribbon colours whilst striking a ball. Findings showed that top of the league players performed well whilst distracted from thinking about performance. “Expert performance is facilitated by an experimental manipulation that has no significant effect on less skilled subjects” (Allard, et al., 1985). The bottom of the league players were very disrupted by the verbal task. This finding suggests that batting for the bottom of the league players requires conscious processing to plan their swing thus reducing the capacity available for a verbal task. Novice players are disrupted by a manipulation that has little effect on the experts players.

Beilock's et al. (2002) study of novice soccer players found that they performed better under the skill-focused conditions and that they benefited from online attention monitoring of step by step performance where the opposite occurred for high level sport participants, with skill execution harmed by consciously processing movements. The results of the indirect evidence of MSR and early learners (Beilock, et al., 2002; Gray, 2004) indicate early learners may benefit from attention to their movements.

1.3.5 Skill acquisition from early learners to experts

The development from early learner to expert is considered to develop in stages with varying attention to the task required. Attention to the task during the early learner stage varies compared to the expert stage. Early learners' performance is easily disrupted if attention is taken away from the task whereas expert performance is often disrupted if attention is directed to the task.

The theoretical framework for skill acquisition initiated by Fitts and Posner (1967) suggests that learning motor skills needs a high level of conscious control of movement by the early learner. Early stages of learning are attention demanding and slow with many errors occurring. As a result, the early learner does not have attention available for dual task activities. The early stage is known as the cognitive stage as it is highly cognitive. However, the skill develops to the autonomous stage of learning where the control of the performance does not rely on attention as the skills are well learnt. At the well learnt stage diverting attention away from cognitive stages is beneficial for performance. High level athletes are at the autonomous stage of learning whilst early learners are at the cognitive stage of learning. The theory for skill learning displays the process as a structured and ordered process that starts out with controlled, conscious and explicit processes of an early learner and later develops into smooth, unconscious movements of an expert.

1.3.6 Reinvestment among children

There is a gap in the literature on sport research surrounding movement specific reinvestment by children. Ling et al. (2016) highlighted the need to investigate movement specific reinvestment by children. While expert adults executing fine motor skills under pressure are likely to experience performance failure if they revert to consciously thinking about how to perform the skill (Masters & Maxwell, 2008), it is less known what effects may occur for children. “We tested children because their natural inclination for movement specific reinvestment can be considered less affected by their motor performance history than adults” (Buszard et al., 2014, p. 353). As children are younger than adults they are more likely to have fewer injury experiences, less coaching experience and fewer skill errors. With less experiences children are more likely to rely on their thoughts.
Evidence supports movement experiences having an effect on propensity for movement specific reinvestment (Masters, & Maxwell, 2008).

Abdollahipour, Wulf, Psotta, and Nieto (2015) indicate instructions from coaches are the most important variable in the process of learning sport skills for children, implying that the way in which a child’s attention is directed affects their skill performance. Experienced children training six hours per week performed a vertical jump with a 180 degree turn in three conditions of external focus, internal focus and control. The external focus instruction was given to focus on the direction in which the tape marker was pointing, the internal focus was instruction to focus on the hand direction after the turn, and control condition was no focus instruction provided. The findings indicated that the external focus condition resulted in both superior movement form and great jump height than the internal focus and control condition. Abdollahipour et al., (2015) findings are consistent with the theory of reinvestment; experienced child gymnasts performed better when they had an external focus of attention (i.e., did not focus their attention on their movements). Abdollahipour (2015) study was different to our study, however, as it used expert performers and not novice level.

Evidence suggests that age might moderate the relationship between reinvestment and performance. In comparison to the adult population, children have limited cognitive resources (Buszard, et al., 2013; Ling, et al., 2016; Tse, & Ginneken, 2017). Findings from Tse and Ginneken (2017) indicate that the role of attentional focus in motor performance may be more complex for children than for adults. The method used to teach the skill should match a child's individual propensity to reinvest. Children with a low propensity to reinvest were expected to show greater improvement in performance of sport activities when distracted from thinking about their movements. Results showed that children with a high propensity to MSR performed better in the internal focus group and children with a low propensity for MSR performed better in the external focus group. van Duijn, Thomas, and Masters, (2019) studied the role of conscious processing during children's motor learning of a golf chipping task. Results indicated that propensity for movement specific reinvestment predicted improvement in accuracy after implicit learning through analogy was introduced. In other words, the style of learning and instructions that were provided affected the improvement rate of skill acquisition. The study of children with MSR (van Duijn, et al., 2019) indicate that motor skill acquisition is more effective when coaches use fewer verbal instructions and that when a child's individual predispositions align with the coach instructions skill acquisition is more effective (Tse, & Ginneken, 2017). The recent studies of MSR and children (Tse, & Ginneken, 2017; van Duijn, et al., 2019) have not explicitly investigated MSR and sport as this study has intended, they have focused on instruction styles of implicit and explicit learning.

1.4 Chapter summary

Evidence supports the view that physical, cognitive and social development are associated with levels of FMS in children and can impact a child's life positively or negatively depending on their level of proficiency (Arede, et al., 2019; Bardid, et al., 2017; Cohen, et al., 2014; Capio, et al., 2015). FMS are tools that can combat problems such as high suicide rates in teenagers, diabetes and obesity if mastered in early childhood. Recreational gymnastic programmes are saturated with activities demonstrating FMS and there is evidence of a strong association between children who participate in recreational gymnastic programmes having high levels of FMS (Field. & Temple. 2017; Rudd. et al.. 2017a; Rudd. et al.. 2017b).

A child's propensity for movement specific reinvestment influences the acquisition of movement skills (Buszard, et al., 2013; Tse, & Ginneken, 2017; van Duijn, et al., 2019), therefore is associated with how children develop FMS and gymnastic skills. A child's propensity to movement specific reinvestment may account for improvements in FMS and gymnastic skills acquisition which will help fight current health problems faced by New Zealand children and provide a clear pathway towards excellence in sport.

1.5 Research Objective

1.5.1 Overall Aim

The present study was conducted in order to examine the association between FMS, gymnastics and movement specific reinvestment, with the intention to understand the role of movement specific reinvestment and gymnastics experience in developing FMS and gymnastics-specific skills in children.

1.52 Research questions and hypothesis

Specifically, given the previous research, the first aim was to ask whether a child's gymnastic experience and propensity for movement specific reinvestment are associated with developmental level of FMS. It was hypothesised that children with a high propensity for CMP and MS-C (movement specific reinvestment) would display lower levels of FMS, and that children with greater experience in gymnastics would have higher levels of FMS. We also expected to observe that the gymnastic experience would be associated with higher FMS locomotor skills than object control skills, as child gymnasts do not practice object control skills during gymnastics.

Second, this research aimed to investigate whether the propensity for movement specific reinvestment accounts for improvement of gymnastic skill acquisition. It was expected that CMP and MS-C would impact children's gymnastic performance. It was hypothesised that a higher propensity for CMP and MS-C (movement specific reinvestment) would be associated with lower levels of gymnastic skill acquisition.

The research also aimed to investigate whether the propensity for movement specific reinvestment changed from week 1 to week 9 of the gymnastic course. It was hypothesised that propensity for movement specific reinvestment would increase from week 1 to week 9 given the nature of gymnastics as a closed skill sport taught within a non-competitive school environment promoting internal focus of attention.

Chapter 2
Methodology

2.1 Participants

Participants consisted of 202 novice gymnasts (*Mean age* = 8.02 ± 2.35 years; range = 5-15 years). Children who attended gymnastic academy programs in the Waikato region of New Zealand were recruited on a voluntary basis. Novice was defined as participants who had no experience of competitive club level gymnastics. Thirty-one percent of the participants had a history of no previous gymnastic experience, fifty-one percent had over one year's previous gymnastic experience with a median of two school terms of previous experience. Children's assent and parental consent were obtained formally during the registration process. Ethics approval was granted from the institutional ethics committee prior to the commencement of the study.

2.2 Set-up and Instructional Philosophy

The participants were enrolled in a nine-week course of gymnastics and were coached by the same person throughout. The weekly one- hour sessions over a nine-week course followed a format of fifteen minutes warm up activities, fifteen minutes flexibility, core strength and basic gymnastic shapes. The second half of the session was split into circuits of progression activities for skills such as the forward rolls and handstand. The progression activities involved beginner, intermediate and advanced level drills. Beginner apparatus was used to practice these skills with lower height beams, soft wedges, barrels and air mats in a comfortable school setting (e.g., school hall or large classroom).

Both implicit and explicit instructions were provided during the gymnastic course. Implicit learning instructions were provided using mainly analogies, such as "roll like a football down a hill" when performing a forward roll progression on a foam incline mat. Explicit learning instructions were provided through verbal instructions and individualised technical feedback (e.g., "tuck your head under and roll on your shoulders" when performing a forward roll). Furthermore, the Socratic method of instruction was also provided by asking leading questions and getting the individual to rationally work through an outcome themselves. Participants were provided with learning through hearing and speaking and learning through visual demonstration performed by the coach and hands on coach support to feel the movement with guided assistance.

2.3 Dependant measures and data analysis

2.3.1 The propensity for conscious processing of movements

Two items from the customised Movement Specific Reinvestment Scale (MSRS; Masters, et al., 2005; Masters & Maxwell 2008) were used to measure individual propensity for conscious processing of movements. The MSRS consists of 10 items designed to evaluate an individual's propensity to be self-conscious about their movements (Movement Self-Consciousness, MS-C subscale) and to consciously control movements (Conscious Motor Processing, CMP subscale).The items are rated on a 6-point Likert scale ranging from 1 (*strongly disagree*) to 6 (*strongly agree*). The scores for each subscale range from 5-30 points with higher scores indicative of higher propensity for conscious processing of movements. The MSRS has been shown to have high internal consistency and test-retest reliability (Masters, & Maxwell, 2008).

The two items used for this study were slightly simplified and presented in a question format to accommodate the young age of our participants. The item from the MS-C subscale "I am concerned about what people think about me when I am moving" became "How much do you think about looking good in front of others?" and the item from the CMP subscale "I am always trying to think about my movements when I carry them out" became "How much do you think about your movements?". The items were rated on a 4-point Likert scale corresponding to 1 (*never*), 2 (*sometimes*), 3 (*often*), and 4 (*always*). The higher scores on this modified MSRS (M-MSRS) scale are associated with higher propensity for conscious motor processing.

2.3.2 Fundamental movement skills

The Test of Gross Motor Development-3rd edition (TGMD-3) was used to assess the fundamental motor skills. The test assesses 13 fundamental motor skills that are divided into two subcategories – locomotor and object control (ball) skills. The locomotor subcategory consists of the following skills – run, gallop, hop, skip, horizontal jump and slide. The object control skills subcategory comprises of the following ball skills – forehand strike of self-bounced ball, kick a stationary ball, overhand throw, underhand throw, two hand strike of a stationary ball, one hand stationary dribble and two hand catch. Each skill is evaluated on three to five performance criteria. Maximum test scores are 46 for locomotor test and 54 for ball skills, with overall total of 100 for gross motor performance.

For the present study, two skills from each category were assessed. For locomotor skills, the performance of slide step and horizontal jump was assessed and for object control skills the performance of one hand stationary dribble and underhand throw was assessed**.** The performance criteria are listed in appendix 5.

2.3.3 Gymnastic-specific skill

The gymnastics skills test (GST) was used to assess the specific gymnastic skills. Maximum test scores are 10 points for rotation and 10 points for balance with an overall score of 20 points for gymnastic performance, that is the forward roll and the handstand skill are performed twice each and judged both times. Each sub-test score can vary from 2 to 10 points with minimum scores of 2 points for rotations and two points for balance and a minimum total of 4 points. Participant skills were judged with video recording for inter-observer reliability.

GST is assessed on a 5-point scale from 1 (poor performance), where performance could not be performed at all, to 5 (excellent performance), where performance was executed without technical error. For the present study, both subcategories were assessed. For rotation the forward roll was assessed and for stability the handstand was assessed. The performance criteria are listed in appendix 6.

The GST is not a validated performance measure currently. The Federation of International Gymnastics (F.I.G) has a code of points with complex criteria for judging high level competition gymnastic routines. At this stage, there is not a current measure for recreational or novice gymnastics. Gymnastic researchers (Culjak, et al., 2014) have modified the F.I.G code of points to fit with beginner level gymnastics assessment. We have done likewise (Appendix 6) with GST, which measures typically developing children's skill level in performing two gymnastic skills, the handstand and the forward roll. These skills represent basic gymnastic skills that must be acquired to reach higher level skills. The performance was video recorded for subsequent analysis. Two independent rates performed the assessment.

2.4 Procedure

Children who attended the Gymnastic Academy programs in the Waikato region of New Zealand and volunteered to take part in this research project (with parental consent) were asked to provide demographic information (e.g., age, gymnastics experience) and complete the M-MSRS at the beginning of the first gymnastic session. To administer the M-MSRS, the researcher read the question aloud and asked the participant to write an answer by circling the box which best described their thoughts. All questions were self-administered with a researcher present to answer any questions and to read aloud the questions to the children. If understanding the questions became an issue the researcher assisted in comprehension issues.

The children then participated in a nine-week gymnastic course which included a one hour gymnastic session per week. The test for assessing children's FMS was integrated into the first gymnastic session. In session two of the gymnastic course, the children were assessed on the two gymnastic skills (forward roll and handstand). The children were then re-assessed for their gymnastic skills in session nine to measure learning and improvement over the eight weeks.

2.5 Data analysis

First, descriptive statistics were calculated to describe the sample and provide results for Week 1 assessment. Normality was tested using Kolmogorov-Smirnov test. The FMS data was not normally distributed as most of the skills were characterised by a ceiling effect. Controlling for age, partial Spearman's product-moment correlation analyses were computed to examine pairwise associations between gymnastics experience, movement specific reinvestment and performance of FMS. Significant correlations were followed up by separate stepwise linear regression analyses. At Step 1, age was entered. At Step 2, variables that were significantly correlated with FMS were entered.

Paired samples t-tests were conducted for gymnastics-specific skills and for movement specific reinvestment (CMP, MS-C) to investigate differences between measurements at Week 1 and Week 9. Change scores were then calculated for gymnastics specific skills and were entered into separate stepwise linear regression analyses to determine the independent contribution of CMP and MSC to skill improvement when controlling for age at Step 1.

Chapter 3
Results

Table 1 presents the characteristics of the participants and their scores for movement specific reinvestment, fundamental movement skills and gymnastic-specific skills at Week 1. Out of 202 children, 196 provided demographic data, 143 completed the FMS assessment and 159 gymnastics-specific skills assessment and movement specific reinvestment scale at Week 1.

3.1 Table 1 Descriptive statistics of study participants

Variables	Mean (SD) or %
Demographic data (*N* = 196)	
Age (yrs)	8.02 (2.35)
Gender	93.1% F; 6.9% M
Experience	31.4% no experience
	3.6% 1-3 sessions
	13.9% 4-10 sessions
	10.3% 11-20 sessions
	8.8% 21-30 sessions
	26.3% 31-40 sessions
	5.7% more than 1 year
Movement Specific Reinvestment (*N*=159)	
CMP	2.62 (0.95)
MS-C	2.32 (0.94)
FMS locomotor (*N* = 143)	
Horizontal jump (/8)	6.75 (1.53)
Slide (/8)	7.62 (1.01)
FMS object control (*N* = 143)	
Dribble (/8)	4.86 (1.90)
Throw (/8)	6.21 (2.05)
Gymnastic skills (*N* = 159)	
Forward roll	2.31 (0.97)
Handstand	1.74 (0.84)

Note: CMP, Conscious Motor Processing; MS-C, Movement Self-Consciousness; FMS, fundamental movement skills

Gymnastics experience, movement specific reinvestment and FMS

When controlling for age, partial Spearman's rank correlation revealed a significant positive correlation between gymnastics experience and Horizontal jump (r = .18, p = .038) (Table 2). No other significant correlations were found (p's > .145).

3.2 Table 2 Correlation matrix for gymnastics experience, movement specific reinvestment (CMP, MS-C) and fundamental movement skills

	Locomotor skills		Object control skills	
	Horizontal jump	Slide	Stationary dribble	Underhand throw
Experience	.18*	.11	.05	.08
CMP	-.03	-.04	-.05	-.04
MS-C	-.11	.02	.13	-.05

Note: CMP, Conscious Movement Processing; MS-C, Movement Self-Consciousness; * $p \leq .05$

Association between gymnastic skill development and movement specific reinvestment

Out of 202 participants, 87 children who were 7 years of age or older completed the gymnastics-specific skills and movement specific reinvestment scale at both Week 1 and Week 9. Gymnastic-specific skills forward roll and handstand significantly improved from Week 1 to Week 9 (Table 3). Furthermore, movement specific reinvestment scores of CMP and MS-C significantly increased from Week 1 to Week 9, suggesting that following the training children tended to consciously engage in movement processing more than prior to the training.

Separate stepwise linear regression analyses were performed for forward roll and handstand to examine the extent to which CMP and MS-C (Week 1) play a role in gymnastic skill development. When age was controlled for at Step 1, a significant regression model was found for forward roll, $F(2,83) = 4.587$, $p = .005$; $R^2 = .066$.

When looking at individual contribution of CMP and MS-C on the development of forward roll, only CMP was found to significantly account for the improvements, with higher scores on CMP associated with less improvement from Week 1 to Week 9, $t(83) = -2.509$, $p = .014$, $\beta = -.261$. MS-C did not significantly account for the improvements in forward roll ($p = .467$). Furthermore, when age was controlled for at Step 1, a non-significant model was found for the handstand, $F(2,83) = 0.627$, $p = .600$.

3.3 Table 3 Comparisons for gymnastic-specific skills and movement specific reinvestment between Week 1 and Week 9

Variable	Week 1	Week 9	*p* value
Forward roll	2.60 (0.99)	3.32 (0.81)	< .001
Handstand	1.97 (0.83)	2.72 (1.02)	< .001
CMP	2.62 (0.88)	3.02 (0.94)	= .001
MS-C	2.37 (0.95)	2.60 (0.97)	= .046

Note: CMP, Conscious Movement Processing; MS-C, Movement Self-Consciousness

Chapter 4

Discussion and conclusion

This study investigated three research questions related to movement specific reinvestment, gymnastic experience, and FMS. The results of the three investigations are discussed below.

The first research question investigated whether a child's gymnastic experience and propensity for movement specific reinvestment was associated with developmental level of FMS. Research has shown that in a sporting context adults with a high propensity for movement specific reinvestment are more likely to experience skill performance failure (Jackson, et al., 2013; Masters, & Maxwell, 2008). Therefore, we expected that a child with high scores on both factors of the MSRS (CMP and MSC) would display lower levels of FMS and gymnastic skills. Research has also shown evidence of a strong positive association between level of gymnastic experience and level of FMS (Field, & Temple, 2017; Rudd, et al., 2017a; Rudd, et al., 2017b). We therefore expected to see a strong association between gymnastic experience and FMS. Additionally, the subcategory of locomotor skills was expected to be more highly associated than the subcategory of object control skills, due to child gymnasts seldom practicing object control skills during their gymnastic course.

4.1 Movement specific reinvestment and fundamental movement skills

We found no significant correlation between movement specific reinvestment and fundamental movement skills in children. Ulrich's highly utilised FMS measure, TGMD-3, has been mainly used for children aged 3-10 years (Ulrich, 2000). A proportion of the children in the current study were slightly older, which might be the reason why we found a ceiling effect for the FMS. The lack of variability in performance measures might explain why we found no associations between FMS and movement specific reinvestment.

4.2 Movement specific reinvestment and gymnastic experience

Part two of the first research question compared children's level of previous gymnastic experience with their FMS scores completed in session one of the gymnastic course. Similar to previous findings (Karachle, et al., 2017; Rudd, et al., 2017a; Rudd, et al., 2017b; Field, & Temple, 2017), the research found that gymnastic experience positively correlated with the FMS subcategory of locomotor skill (horizontal jump) and was significant at 5% level of significance. There was no significance with slide step nor the object control skill tests of dribbling and throwing a ball. The findings of no significance with object control skills is consistent with other research (Culjak, et al., 2014; Field, & Temple, 2017); however, differ from the studies conducted by Rudd (2017) who found significance with gymnastics and object control skills. Past research is disputed about the FMS subcategory of object control skills increasing with gymnastic experience. The current research predicted that gymnastic experience would lead to higher levels of FMS specifically with the subcategory of locomotor skills. However, the results in this study are not reliable as only one of the two locomotor skills were significantly correlated with gymnastic experience.

An explanation of the FMS discrepancies between past research and our current results is that the Rudd et al.(2017b) study included object control activities within the gymnastic course, such as ball throwing and passing, blind tennis, passing balls, juggling balls, basketball, badminton and javelin activities. The gymnastic course for this current study was artistic gymnastics so did not include ball control activities or rhythmic gymnastics, that is consistent with other studies (Culjak, et al., 2014; Field, & Temple, 2017; Fallah, et al., 2015).

An explanation for the lack of significant associations between gymnastic experience and FMS is that the age group of the sample was 5-15 years. The FMS skills are basic and children begin learning them early, from 3 years old onwards. The FMS scale does not allow for great enough differentiation in movement skill acquisition, in that many children in the sample have already reached maximum scores. Any small experience children have in gymnastics gives them the ability to master FMS. Therefore a ceiling effect is likely to occur as children have reached the highest scores possible, thereby decreasing the ability to differentiate participants on FMS.

4.3 Movement specific reinvestment and gymnastic skill acquisition

The second research question investigated whether a child's propensity to reinvest accounts for improvement of gymnastic skill acquisition. Research on reinvestment with children showed improvement in the performance of a golf chipping task (van Duijn, et al., 2019) and reinvestment of children playing darts has been researched (Tse, & Ginneken, 2017). Both of these studies draw upon improvements on object control motor skill tasks when a child's attention is free from consciously monitoring and controlling their movements. There have been no previous studies that have investigated the relationship between movement specific reinvestment and gymnastics in children. At the well learnt stage diverting attention away from conscious engagement in movement is beneficial for performance. Therefore, we expected that lower scores on both factors of the MSRS (CMP and MSC) would be associated with higher levels of gymnastic skill acquisition. This is consistent with reinvestment theory (Masters, & Maxwell, 2008).

The results indicated that CMP was negative and significantly correlated with the forward roll improvement from week one to week nine at the 5% level of significance. The change in handstand skill was not significantly correlated with either MSRS scores of CMP or MS-C. The results of the study are consistent with previous literature (Masters, & Maxwell, 2008; Jackson, et al., 2013) on sport performance and reinvestment theory in that the higher a person's propensity to consciously process their movements the lower their sport performance level.

Up to this point, other movement specific reinvestment studies have investigated sports with an external focus of attention involving object control, such as, golf (Malhotra, et al., 2015a; van Duijn, et al., 2019), tennis (Buszard, et al., 2013) or darts (Tse, & Ginneken, 2017). As previously stated in the introduction, gymnastics is a demonstration sport where participants display their body movements to gain scores and are judged on how their movements appear. This study is one of the first movement specific reinvestment studies of a demonstration sport predominantly using locomotor skills and stability skills as opposed to object control skills. The results of this study indicate that movement specific reinvestment applies to demonstration sports, such as gymnastics as well as object control sports.

There was no correlation between MS-C and either gymnastics skills. The lack of correlation could be explained by the lack of a pressured environment in which the child performed the sport. Halliburton, and Weiss (2002) demonstrated that the environment the sport is performed in impacts on the children's acquisition of skill. The association of reinvestment and poor performance was developed from the original writings of Masters et al. (1993) that considered reinvestment in environments of pressure (Masters, & Maxwell, 2008). However, "… gymnastics is inherently task-oriented, meaning that skills are practiced and developed in a non-pressured environment" (Rudd, 2017b, p. 92). Gymnastics in school occurs in a non-competitive or low pressured environment that may differ from other school sports, such as team sports where children win or lose games. This environment may be viewed as less threatening by children and associated with positive outcomes due to its non-competitive and low pressure environment.

The instructional learning environment could also explain the lack of relationship between MSC and gymnastic skills. The learning environment in the study of Tse and Ginneken, (2017) provided the highest performance of high reinvestors with internal focus of instruction. The highest performance of low reinvestors was with external focus of instruction, with neither significant difference between the high and low reinvestors. This current study of gymnasts provided both internal and external focused instructional learning conditions, allowing an environment for both high and low reinvestors to perform well on skill acquisition. Thereby, the performance difference between high and low reinvestors cannot be significantly distinguished.

The statistically significant associations between reinvestment and gymnastics in this study only occurred on the forward roll. For the handstand skill, the current scoring scale may have underscored advanced performers. Many children who achieved a vertical handstand with good body posture (scoring 4 or 5 points) continued past vertical and performed a handstand forward roll skill instead of returning to their feet, thus scoring only 2 points. The handstand test could have included participants performing a handstand into forward roll without penalty as it also demonstrates an advanced skill level.

4.4 Movement specific reinvestment change

The results to the third research question were that children's scores on both factors of the MSRS (CMP and MSC) increased significantly throughout the nine week course of gymnastic training. The variables age and experience were considered constant and controlled for so do not account for the changes in CMP and MS-C. Therefore, the change in scores is explained by something other than age or experience. This current study is the only movement specific reinvestment study that assesses a change in movement specific reinvestment in children playing sport. Further investigation could identify whether that is due to the coaching style or the peculiarities of gymnastics itself. Previous movement specific reinvestment research (Capio, et al., 2018b) found that physiotherapists (professionals who work with movement for a living), had a higher propensity for MS-C than professionals who did not work with movement (whether they were experienced or inexperienced physiotherapists). There is a possibility that gymnasts have a higher propensity for movement specific reinvestment than other sport participants because they need to be preoccupied with the appearance of their movements in order to perform successfully. Future research could assess the propensity for movement specific reinvestment differences across sport codes.

In addition to the specific sport of gymnastics, increased scores on the MSRS (CMP and MSC) during the course may be due to the instructional coaching style as the gymnastics course in this study provided internal and external focus instructions to benefit the children. As described above, instructional style impacts performance. The Tse and Ginneken (2017) study showed that children appeared to be more effective when the teaching style matched the child's natural propensity. Several researchers (van Dujin, et al., 2019; Masters, & Poolton, 2012; Buszard, Farrow, Zhu, & Masters, 2016) also indicate teaching movements to novice children using analogy instruction (implicit learning) may be effective. Researchers (Tse, Fong, Wong, & Masters,, 2017) indicate if children are given analogy instruction, thus freeing up their working memory resources, it is likely that children, particularly those aged 5 to 7, who tend to have slower processing speed, might benefit. For example, Tse, et al., (2017) found that analogy instructed children demonstrated better skipping and more stable performance than a control group of children who learned with explicit instructions. Research on implicit motor learning in children might provide greater understanding of why the child gymnasts in this study increased their propensity for movement specific reinvestment when both age and experience were constant.

Apart from those studies described above, movement specific reinvestment has received limited research in children playing sport (van Dujin, et al., 2019; Tse & Ginneken, 2017). There has been limited research of instruction impacts on performance for high and low reinvestors. Instructions in the coaching courses maybe impacting MSRS and this requires further investigation.

However, children have limited cognitive resources and are unable to process explicit instructions when learning new skills (Tse, & Ginneken, 2017). Children are learning, developing learning styles and cognitive abilities. The working memory capacity in children aged 8-12 years is also still developing (Buszard, et al., 2013). Thus, reinvestment as a conscious and cognitive function may still be developing in children. Reinvestment may be fluid in children and not fixed as presumed in reinvestment studies of adults. For this reason, caution should be exercised with research of reinvestment in children.

As described above, the limitations of this study included the operational scoring of the gymnastic handstand skill and the selection of scoring attempts. The handstand gymnastic skill test scoring system might not have captured the full range in performance, as children with good vertical handstands only scored two points instead of five points if they did not land on their feet first. Second, the gymnastic skill test recorded only the best of the two attempts for a score from 1-5. Instead, both gymnast attempts could have been recorded, to operationally measure for consistency and stability of performance. The resulting score would then range from 2-10, to provide greater variation in scores so any significant differences of scoring results are exaggerated.

The practical implication of the study results that CMP is negatively associated with improvements in performance is that children performance is highest with low movement specific reinvestment propensity. Also, the results that movement specific reinvestment propensity increased significantly throughout the gymnastic course, indicates that reinvestment propensity changes and can be influenced, potentially through instruction. Thus, skill performance can be improved with coaching instruction that develops low reinvestors. Coaching needs to reduce the amount of instruction that requests children to consciously be aware of their appearance and movements. Rather than explicit instruction, instructions could be implicit. Potential implicit teaching methods could include errorless learning (Poolman & Masters, 2010), analogies (van Dujin, et al., 2019), or dual task learning (Masters, 1992).

4.5 Conclusion

To conclude, this study has shown that children who participate in gymnastic courses show high levels of FMS with gymnasts achieving fundamental skills so a ceiling effect takes place. This study also found that conscious motor processing was associated with improvement in gymnastic performance of the forward roll skill. Children with a low propensity for CMP showed greater improvements in gymnastic performance of the forward roll. For future research of reinvestment of children a recommendation is for the gymnastic skill tests (GST) to be modified and utilised to measure the three sub-categories of locomotor skills, object control skills and stability skills with a wider scoring range than 1-5 (i.e., 1-10), to allow for a greater differentiation of results that can also accommodate children older than 10 years. To end, this study found children's propensity to reinvest evolves and increased throughout the gymnastic course. Coaching and instruction might be a factor that impacts on children's movement specific reinvestment. The recommendation is to research further into learning styles with implicit learning through analogies and the association with movement specific reinvestment in child gymnasts.

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Appendices

Appendix 1 – Ethics approval

The University of Waikato
Private Bag 3105
Gate 1, Knighton Road
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Human Research Ethics Committee
Karsten Zegwaard
Telephone: +64 7 838 4892
Email:humanethics@waikato.ac.nz

THE UNIVERSITY OF WAIKATO
Te Whare Wānanga o Waikato

18-12-2018

Marie Connolly
By email: marie@gymnasticacademy.co.nz

Dear Marie

Dear Marie

UoW HREC(Health)2018#88: Fundamental Motor Skills and Movement Specific Reinvestment in Gymnastics

Thank you for submitting your amended application HREC(Health)2018#88 for ethical approval.

We are now pleased to provide formal approval for your project within the parameters outlined within your application.

Please contact the committee by email (humanethics@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.

Regards,

Karsten Zegwaard PhD
Acting Chairperson
University of Waikato Human Research Ethics Committee

Appendix 2 – Participant information sheet.

Project Title

Participant Information Sheet

Fundamental Motor Skills and Movement Specific Reinvestment in Gymnastics

Purpose

This research is conducted as partial requirement for *Master of Health, Sport and Human performance; specifically, for the Master's thesis.* This project requires the researcher to conduct research on a topic of choice. This is conducted by the use of questionnaires, and an assessment of both fundamental motor skills and gymnastic skills.

What is this research project about?

This research aims to investigate whether there is an association between propensity for movement specific reinvestment (MSR) and fundamental motor skills (FMS) of child gymnasts.

What will you have to do and how long will it take?

The researcher will want the participant to complete a survey questionnaire and then participate in FMS as a part of their structured class session. This should take no longer than 45 minutes in total as a part of the first Gymnastic Academy session. The researcher will want the participate to perform two gymnastic skills (handstand and forward roll) in week two and week nine of the program. You will be asked to give consent prior to the experiment during the registration process.

What will happen to the information collected?

The information collected will be used by the researcher to write a research report in the form of a Master's thesis. It is possible that articles and presentations may be the outcome of the research. Only the researcher *and supervisor* will be privy to the notes, documents, recordings and the paper written. Afterwards, notes, documents will be destroyed, and recordings erased. The researcher will keep recordings and a copy of the paper but will treat them with the strictest confidentiality. No participants will be named in the publications and their identity is hidden.

Declaration to participants

If you take part in the study, you have the right to:

- ● Refuse to answer any particular question, and to withdraw from the study before analysis has

  commenced on the data, at any time.

- ● Ask any further questions about the study that occurs to you during your participation, at any time.
- ● Be given access to a summary of findings from the study when it is concluded.

Who's responsible?

If you have any questions or concerns about the project, either now or in the future, please feel free to contact: Researcher: Dr. Liis Uiga (liis.uiga@waikato.ac.nz)

Appendix 3 – Informed consent

Fundamental Motor Skills and Movement Specific Reinvestment in Gymnastics

Consent Form for Participants
I have read and understand the **Participant Information Sheet** for this study. My questions about the study

have been answered to my satisfaction, and I understand that I may ask further questions at any time. I also understand that

Please Tick:

a) I am free to withdraw my child from the study before completion of data collection on Friday 12the April, or to decline to answer any particular questions in the study. I understand I can withdraw any information I have provided up until the researcher has commenced analysis on my data; or

b) I am free to withdraw my child from the study at any time, or to decline to answer any particular questions in the study. I understand I can withdraw any information I have provided up until the research being sent for publication

Signed: Name: Date:

I agree to participate in this study under the conditions set out in the **Participant Information Sheet**.

____
____
____

Researcher's Name and contact information:
Liis Uiga (liis.uiga@waikato.ac.nz)Supervisor's Name and contact information: Prof R Masters (rich.masters@waikato.ac.nz)

Appendix 4 – Modified Movement Specific Reinvestment Scale Questionnaire for Children

NAME: ________________________

Below are two questions about your movements. There are no right or wrong answers so circle the answer that best describes how you feel for each question.

1. How much do you think about your movements?

Never	Sometimes	Often	Always

2. When you move, how much do you think about looking good in front of others?

Never	Sometimes	Often	Always

Appendix 5 – Test of gross motor development (3rd edition)

Test of Gross Motor Development (3rd edition)

TGMD-3 form for collecting norms

Child's Name or ID #:				
Country:	City or Town:		State & Zip Code (if USA):	
Male: ☐	Female: ☐	Disability: Yes ☐ No ☐	If yes, what disability:	Date of Testing:
Child's Date of Birth:		Child's Age in Years and Months:		
Examiner's Name:	Affiliation:		Examiner's email address:	
Estimate of child's family Socioeconomics status: Low ☐ Mod. ☐ High ☐		Child's Race: White ☐ Hispanic ☐ Black ☐ Asian ☐ Mixed ☐		
Child's Residential Location: City ☐ Suburb of City ☐ Rural or Small Town ☐				
Child's Preferred Hand: Right ☐ Left ☐ Not established ☐		Child's preferred foot: Right ☐ Left ☐ Not established ☐		
Child's weight status: Underweight ☐ Normal ☐ Overweight ☐ Very Overweight ☐				

LOCOMOTOR SUBTEST

Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
1. Run	60 feet (18.3 m) of clear space to run, 2 cones or markers.	Place 2 cones 50 feet (15.2m) apart. Make sure there is at least 8-10 feet (2.4-3.1m) of space beyond the cone for a safe stopping distance. Tell the child to run fast from one cone to the other cone when you say "GO". Repeat a second trial.	1. Arms move in opposition to legs with elbows bent.			
			2. Brief period where both feet are off the surface.			
			3. Narrow foot placement landing on heel or toes (not flat-footed).			
			4. Non-support leg bent about 90 degrees so foot is close to their buttocks.			
				Skill Score:		
2. Gallop	25 feet (7.6m) of clear space, 2 cones or markers.	Place 2 cones 25 feet apart. Tell the child to gallop from one cone to the other cone and stop. Repeat a second trial.	1. Arms flex and swing forward to produce force.			
			2. A step forward with lead foot followed with the trailing foot landing beside or a little behind the lead foot (not in front of the lead foot).			
			3. Brief period where both feet come off the surface.			
			4. Maintains a rhythmic pattern for 4 consecutive gallops.			
				Skill Score:		

Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
3. Hop	A minimum of 15 feet (4.6m) of clear space, 2 cones or markers.	Place 2 cones 15 feet apart. Tell the child to hop 4 times on his/her preferred foot (established before testing). Repeat a second trial.	1. Non-hopping leg swings forward in pendular fashion to produce force.			
			2. Foot of non-hopping leg remains behind hopping leg (does not cross in front of).			
			3. Arms flex and swing forward to produce force.			
			4. Hops 4 consecutive times on the preferred foot before stopping.			
					Skill Score:	
4. Skip	A minimum of 30 feet (9.1m) of clear space, 2 cones or markers.	Place 2 cones 30 feet apart. Mark off two lines at least 30 feet apart with cones/markers. Tell the child to skip from one cone to the other cone. Repeat a second trial.	1. A step forward followed by a hop on the same foot.			
			2. Arms are flexed and move in opposition to legs to produce force.			
			3. Completes 4 continuous rhythmical alternating skips.			
					Skill Score:	
5. Horizontal jump	A minimum of 10 feet (3.1m) of clear space, tape or markers.	Mark off a starting line on the floor, mat, or carpet. Position the child behind the line. Tell the child to jump far. Repeat a second trial.	1. Prior to take off both knees are flexed and arms are extended behind the back.			
			2. Arms extend forcefully forward and upward reaching above the head.			
			3. Both feet come off the floor together and land together.			
			4. Both arms are forced downward during landing.			
					Skill Score:	
6. Slide	A minimum of 25 feet (7.6m) of clear space, a straight line and 2 cones or markers.	Place 2 cones 25 feet apart on a straight line. Tell the child to slide from one cone to the other cone. Let the child decide which direction to slide in first. Ask the child to slide back to the starting point. Repeat a second trial.	1. Body is turned sideways so shoulders remain aligned with the line on the floor.			
			2. A step sideways with the lead foot followed by a slide with the trailing foot where both feet come off the surface briefly.			
			3. 4 continuous slides to the preferred side.			
			4. 4 continuous slides to the non-preferred side.			
					Skill Score:	

Locomotor subtest total score: ________

BALL SKILLS SUBTEST

Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
1. Two-hand strike of a stationary ball	4 inch (10.2cm) plastic ball, plastic bat, and a batting tee or other device to hold ball stationary.	Place ball on batting tee at child's waist level. Tell child to hit the ball hard, straight ahead. Point straight ahead. Repeat a second trial.	1. Child's preferred hand grips bat above non-preferred hand.			
			2. Child's non-preferred hip/shoulder faces straight ahead.			
			3. Hip and shoulder rotate and derotate during swing.			
			4. Steps toward ball with non-preferred foot.			
			5. Hits ball sending it straight ahead.			
				Skill Score:		
2. One-hand forehand strike of self-bounced ball	Tennis ball, light plastic paddle, and wall.	Hand the plastic paddle and ball to child. Tell child to hold up ball and drop it (so it bounces about waist height); off the bounce, hit the ball toward the wall. Point toward the wall. Repeat a second trial.	1. Child takes a backswing with the paddle when the ball is bounced.			
			2. Steps toward the ball with non-preferred foot.			
			3. Strikes the ball toward the wall.			
			4. Paddle follows through toward non-preferred shoulder.			
				Skill Score:		
3. One-hand stationary dribble	An 8-10 inch (20.3-25.4cm) playground ball for ages 3-5 years; a basketball for ages 6-10 years; flat surface.	Tell the child to bounce the ball 4 times without moving their feet, using one hand, and then stop by catching the ball. Repeat a second trial.	1. Contacts ball with one hand at about waist level.			
			2. Pushes the ball with fingertips (not slapping at ball).			
			3. Maintains control of the ball for 4 bounces without moving their feet to retrieve the ball.			
				Skill Score:		
4. Two-hand catch	A 4 inch (10.2cm) plastic ball, 15 feet (4.6m) of clear space, tape or marker.	Mark off 2 lines 15 feet apart. The child stands on one line and the tosser stands on the other line. Toss the ball underhand to the child aiming at the child's chest area. Tell the child to catch the ball with 2 hands. Only count a trial where toss is near child's chest. Repeat a second trial.	1. Child's hands are positioned in front of the body with the elbows flexed.			
			2. Arms extend reaching for the ball as it arrives.			
			3. Ball is caught by hands only.			
				Skill Score:		

Skill	Materials	Directions	Performance Criteria	Trial 1	Trial 2	Score
5. Kick a stationary ball	An 8-10 inch ball (20.3-25.4cm); plastic, playground, or soccer ball), tape or marker, a wall, and clear space for kicking.	Mark off 1 line about 20 feet (6.1m) from the wall and a second line 8 feet (2.4m) beyond the first line. Place the ball on the first line closest to the wall. Tell the child to run up and kick the ball hard toward the wall. Repeat a second trial.	1. Rapid, continuous approach to the ball.			
			2. Child takes an elongated stride or leap just prior to ball contact.			
			3. Non-kicking foot placed close to the ball.			
			4. Kicks ball with instep or inside of preferred foot (not the toes).			
					Skill Score:	
6. Overhand throw	A tennis ball, a wall, 20 feet (6.1m) of clear space.	Attach a piece of tape on the floor 20 feet from the wall. Have the child stand behind the tape line facing the wall. Tell the child to throw the ball hard at the wall. Repeat a second trial.	1. Windup is initiated with a downward movement of hand and arm.			
			2. Rotates hip and shoulder to a point where the non-throwing side faces the wall.			
			3. Steps with the foot opposite the throwing hand toward the wall.			
			4. Throwing hand follows through after the ball. Release across the body toward the hip of the non-throwing side.			
					Skill Score:	
7. Underhand throw	A tennis ball, tape, a wall, and 15 feet (4.6m) of space.	Attach a piece of tape 15 feet from the wall. Have the child stand behind the tape line facing the wall. Tell the child to throw the ball underhand and hit the wall. Repeat a second trial.	1. Preferred hand swings down and back reaching behind the trunk.			
			2. Steps forward with the foot opposite the throwing hand.			
			3. Ball is tossed forward hitting the wall without a bounce.			
			4. Hand follows through after ball release to chest level.			
					Skill Score:	

Ball Skills subtest total score: ________

Scoring Notes

- Directions for all test items require you to first give the child a good demonstration of the skill, which includes all of the performance criteria; give the child a practice trial, followed by 2 test trials that you score.

- Score each performance criterion as:
  - 1 = performs correctly
  - 0 = does not perform correctly

- **Performance criteria scores** are calculated by summing the score on trial 1 and trial 2 for each performance criterion.

- **Skill scores** are calculated by summing all of the performance criteria scores for each skill.

- The total **locomotor subtest score** is calculated by summing all 6 locomotor skill scores.

- The total **ball skills subtest score** is calculated by summing the 7 ball skills scores.

- The total **gross motor test score** is calculated by summing the total locomotor subtest score and the total object control subtest score.

- We have learned that test administrator bias occurs when the tester is unsure how to score a performance criterion. When testing a child, if you are unsure of whether the child performed a performance criterion correctly, administer another trial and just look at that performance criterion and score it.

- It is recommended that when testing children with a disability or very young children who appear to be distracted easily, to have them stand on a small poly spot or other marker and tell them to stand on the marker and watch your demonstration. It is also helpful to use another poly spot or marker as the child’s starting position for the locomotor skills. Giving these children more structure during your testing should be helpful.

Appendix 6 – Gymnastic Skill Test (GST)

Introduction

Children investigate balancing in various forms. Basic balancing activities include shoulder balancing, walking along a beam in various directions (lower in height for beginners), standing on one leg in a scale balance or partner balancing. Advanced recreational balance activities include balancing on one's head or hands in a headstand or handstand position (also on apparatus of a bar or beam). Landing is also an important movement in recreational gymnastics. Children practice basic landing activities of jumping forwards, backwards, twisting during flight or making various shapes with their body parts and landing safely on two feet. Children learn proper landing technique to help reduce the forces of landing. These landings are controlled to stop a movement or dismount from the apparatus safely. Landing can also be due to an error or a fall.

Rolling also teaches children how to fall safely without injuring themselves. Rolling and rotational activities are also common in recreational gymnastics. Basic activities include a sausage roll (maintaining a straight body position and rolling sideways) or a forward roll down a soft inclined mat. Advanced activities include backward roll to handstand, dive roll or a handstand forward roll (also on the beam). Rolling techniques are also taught on how to fall safely. Safety rolls allow children to absorb the impact of a fall. Rolling is a life skill that teaches children how to fall without injuring their self. These general gymnastic activities used in recreational classes have progression exercises to move from beginner, intermediate and advanced skill level. For example, learning a handstand at a beginner level would involve walking your feet up a mat or rolling over a barrel and taking your weight on your hands. Intermediate level progression drills include performing a ¾ handstand or donkey kick towards handstand and advanced practice would include stepping into a full handstand with and without coach support.

The gymnastics skills test (GST) was used to assess the specific gymnastic skills. The test assesses two gymnastic skills that are divided into two subcategories – rotation and balance. The rotation subcategory consists of the forward roll skill and the stability (balance) subcategory comprises of the handstand skill. The handstand was examined because it is a popular, enjoyable gymnastic activity that can be performed on a school field at no cost and benefits children's physical activity during playtime and improves their stability (balance), co-ordination, flexibility and strength. The handstand represents a basic gymnastic skill that teaches stability (balance).The forward roll is less frequently performed outside of structured class time due to the nature of requiring soft or padded mats to roll on. The forward roll represents a basic gymnastic skill that benefits children's postural control, co-ordination and ability to fall safely. Each skill is evaluated on five performance criteria.

Balance Subtest

Skill	Material	Directions	Performance Criteria	Trial 1	Trial 2	Score
Handstand	Air Mat, Tape	Mark off a starting line on the air mat. Position the child behind the line. Tell the child to try a handstand. Repeat a second trial.	1. Straight body with arms to vertical 2. Step on favorite leg and reach hands to mat shoulder width apart facing forwards 3. Kick back leg to vertical and take body weight on hands keeping arms straight 4.Join legs at vertical position 5. Step back down on same leg 6. Finish with straight body position and arms vertical.			

Performance Criteria:
1. Preparation phase where body is in straight position with arms vertical
2. Long lunging step forwards with arms fully extended reaching towards to floor
3. Hands are flat on the floor shoulder width apart with straight arm position
4. With a continuous movement the lunging leg pushes off the floor as the back-leg kicks towards vertical handstand position.
5. Legs join together with toes touching showing shoulders, hips and feet in a vertical line i.e. handstand position.
6. Legs separate with preparation to step down and bring arms back to straight body finishing position in a continuous movement.

Rotation Subtest

Skill	Material	Directions	Performance Criteria	Trial 1	Trial 2	Score
Forward Roll	Air Mat, Tape	Mark off a starting line on the air mat. Position the child behind the line. Tell the child to try a handstand. Repeat a second trial.	1. Straight body with arms to vertical 2. Bend knees and place hands on floor 3. Push feet off floor and Tuck head under and roll over shoulders 4.Tuck knees to stand up using feet only 5. Finish with straight body position and arms vertical.			

Performance Criteria:
1. Preparation phase where body is in straight position with arms vertical
2. Squat to a crouching position
3. Hands are flat on the floor reaching forwards
4. With a continuous movement legs stretch and head under as the child rolls along their shoulders and back in a tucked position
5. Feet touch the floor as the child pushes to stand up and finish skill.

Scoring Notes

- Directions for both test items require you first give the Child a good demonstration of the skill, which includes all of the performance criteria; give the Child a practice, followed by 2 test trials that you score.
- Score each performance criterion as:
    - 1 = Did not complete
    - 2= Performed with major errors
    - 3= Performed with medium errors
    - 4= Performed with minor errors
    - 5= Performed with no errors

- **Skill score is** calculated by summing the best score of the two trials
- The total **gymnastic skills test score** is calculated by summing the skill score for the balance subtest (Handstand) and rotation subtest (Forward roll).

Handstand Score Chart

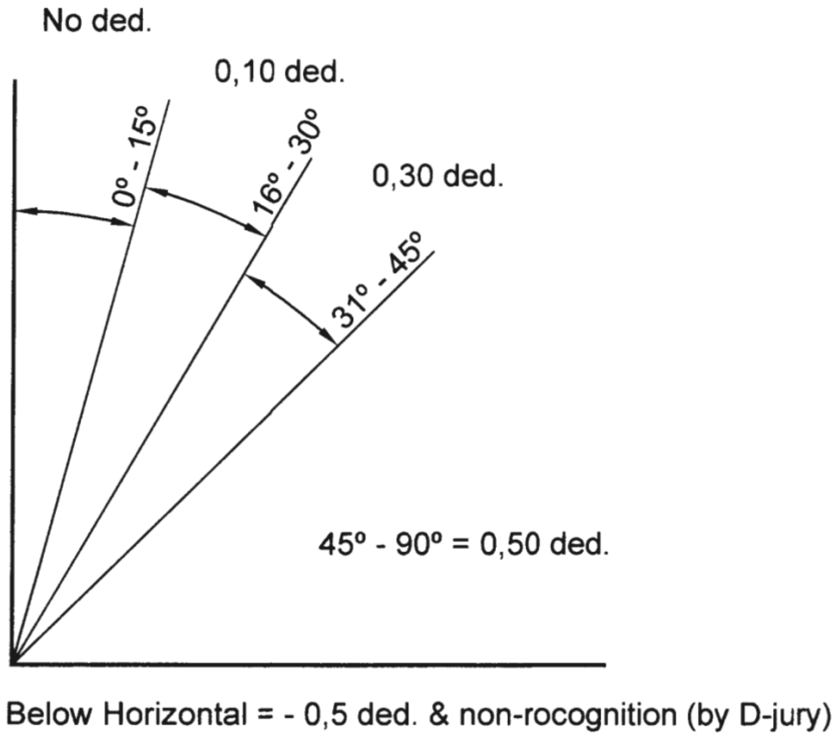
Evaluation of the handstand will be based on the F.I.G (International Gymnastics Federation) code of points but adjusted in order to be suitable for recreational gymnastics. The scale will be used accordingly:

Points	**Performance Criteria**
1 – Skill not completed	• Could not take weight on hands without feet leaving the floor • Could not return to their feet after completing attempt • Returns with two feet landing
2 Points – Large Technical Errors	• Feet below 45 degrees from vertical. • Poor body form , hollow back or bent arms with large errors • Legs do not join together • Does not step off one foot into handstand or return with same foot • Fell over vertical in handstand
3 Points – Medium Technical Errors	• Feet below 30 degrees from vertical • Poor body form , hollow back or bent arms with medium errors • Walks on hands in handstand • Legs join together • Steps into handstand and returns with same foot
4 Points – Minor Technical Errors	• Legs join within 15 degrees of vertical • Poor body form , hollow back or bent arms with minor errors • Minor adjustment of feet on landing • Must start and return to straight body position with arms at vertical position
5 Points – No Technical Errors	• Legs join within 15 degrees of vertical • Tight body form required with no errors • Must start and return to straight body position with arms at vertical position • No feet adjustments on landing

General Judgements Summary
1 Point Child does not compete movement or lands on two feet at same time
2 Points Child takes weight on hands and returns to one foot but may switch legs and return on opposite foot
3 Points Child returns on same leg and shows legs together position before returning with or without shuffles on hands
4 Points Child shows legs together position with straight body position and feet joined within 15-30 degree with no hand movements
5 Points Child maintains a straight body position 0-15 degrees with compete control on return and no adjustments.

Chart for measure of body position from Handstand:

0-15 degrees = 5 points
15-30 degrees = 4 points
30-45 degrees = 3 points
Below 45 degrees = 2 point



Forward Roll Score Chart

Evaluation of the handstand will be based on the F.I.G (International Gymnastics Federation) code of points but adjusted in order to be suitable for recreational gymnastics. The scale will be used accordingly:

Points	Performance Criteria
1 – Skill not completed	• Child could not perform roll • Child rolled off to the side and did not compete forward movement • Child could not complete skill to finish stood up on feet.
2 Points – Large Technical Errors	• Child steps off one foot into roll • Head touches the mat during the roll • Child opens out of tuck to a sitting position on mat before standing up • No placement of hands on mat going into the roll • Child does not maintain tuck shape • No continuous movement with a pause or hesitation to complete skill • Child uses hands or knees to complete the skill to stand up • Child stands up one foot at a time instead of both feet together
3 Points – Medium Technical Errors	• Child maintains tuck position • Hands are not facing forwards flat on the mat • Feet and legs have separation • Forward roll deviates from straight line • Child finishes roll without use of hands or knees to stand up. • Shows rhythm throughout movement
4 Points – Minor Technical Errors	• Legs remain close together through out • Child shows stretched legs pre-roll phase • Childs shows tuck position before standing up • Continuous movement throughout skill with good rhythm • Child completes movement without the use of hands or knees to stand up in a continuous movement. • Minor adjustment of feet on landing
5 Points – No Technical Errors	• No error • Child shows straight legs and flight before hands reach mat • Child shows open hip position and rounded back • No foot adjustment on landing

General Judgements Summary
1 Point Child does not compete movement
2 Points Child completes roll but uses hands or knees to stand up
3 Points Child completes roll to feet in one continuous movement with no additional use of hands to stand up
4 Points Child completes roll with stretched leg position before tucking to stand up in one continuous movement
5 Points Childs completes roll with stretched leg position , flight from feet to hands and open hips in dish position.