The FIFA 11+ Part 2: Can it be improved to further enhance physical performance in female football players?

James Simon Farr

BSc (Hons)

A thesis submitted to Auckland University of Technology in fulfilment of the requirements for the degree of

Master of Philosophy (MPhil)

2023

School of Sport and Recreation

Abstract

The purpose of this study was to determine if a rescheduled, modified FIFA 11+ part 2 would improve physical performance measures in female footballers in comparison to a rescheduled, original FIFA 11+ part 2. The study used a cluster randomised controlled trial approach with an eight-week intervention. A total of 25 female footballers from 4 women's teams in the Wellington region, New Zealand, participated in the study, and were placed into either an intervention group (INT) or a control group (CON) (INT: n= 13, age 24.9 ±4.0 years; height 164.9 ±5.8 cm; weight 68.1 ±8.0 kg; CON: n= 12, age 20.1 ±4.6 years; height 165.1 ±4.6 cm; weight 62.4 ±9.0 kg). Performance measures included adductor strength, 5m, 10m, and 20m linear sprints (split times), 505 change of direction (COD) speed, and jump performance (vertical and reactive strength index). The primary modifications to the FIFA 11+ part 2 (INT) were exercise variations to the corresponding exercise in the original FIFA 11+ (CON), and a reduction in the number of progressions for each exercise. A 2-way repeated measures analysis of variance (RMANOVA) was used to detect within group and between group differences, and whether a group×time effect was present. Omega squared (ω^2) and Cohen's d were used to report the magnitude of the effects as appropriate. There were statistically significant between-group differences (magnitude trivial to small), in favour of the INT (modified FIFA 11+), in adductor strength (ω^2= 0.05; $p \leq$ 0.001), 5 m sprint time (ω^2= 0.04; p= 0.02), 20m sprint time (ω^2= 0.02; p= 0.04), the 505 COD deficit non-preferred foot time (ω^2= 0.07; p= 0.01), and the 505 COD deficit preferred foot time (ω^2= 0.21; $p \leq$ 0.001). The results showed that the implementation of a rescheduled, modified FIFA 11+ programme over an eight week intervention period is as effective at improving some specific physical performance measures in female footballers as a rescheduled, original FIFA 11+ programme. It is recommended that the modified FIFA 11+'s part 2 could be used independently by recreational athletes in football or other team-based sports to assist with developing baseline physical performance qualities if there is not an appropriately structured programme in place.

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Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

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James Simon Farr

Acknowledgements

The last two years have been challenging with many highs and lows. The process to complete this has been harder than I expected, yet enjoyable and rewarding. I want to thank my supervisors Professor Michael McGuigan and Associate Professor Chris Whatman for their continued support and patience. Your knowledge and expertise has been priceless along this journey, and I am eternally thankful for your guidance. I also want to thank Dr Matthew Cross for his input in the statistical analysis process that ensured I maintained clarity and my sanity.

I would like to acknowledge New Zealand Football for funding this research, and the football players and staff in the Wellington region that participated and put up with the constant badgering from me through email and text message. This study would not have been possible without you. I also want to express my deepest gratitude to Dave Wildash and the Hurricanes for their help with providing testing equipment throughout the process. Dave's flexibility to provide assistance at the drop of a hat was hugely appreciated.

I want to thank Kym for her unconditional support and encouragement throughout this process and putting up with my late night and weekend writing sessions. All the sacrifices on your part, whilst this has been taking place, has shown me how lucky I am!

Finally, to my family and friends, near and far. Your continued kindness has meant so much to me and I will forever be in debt to you all.

Ethics Approval

Ethical approval for this thesis research was granted by the Auckland University of Technology Ethics Committee (AUTEC) on 6th July 2021 for a period of three years:

• AUTEC: 21/177- The FIFA 11+ Part 2: Can it be improved further to enhance performance in female youth football players?

Chapter 1: Introduction

The Sport of Association Football

Football, also known as association football or soccer is the most popular sport in the world (FIFA, 2007). It is a sport played between two teams of 11 players on a field of play with dimensions ranging from 90-120 metres (m) in length (touchline) and 45-90m in width (goal line) (IFAB, 2022). Players are allowed to use any part of their bodies, except their hands and arms to manoeuvre the football into the opposition team's goal. The goalkeeper for each team is the only player allowed to handle the ball within the penalty area surrounding their respective team's goal. The team that scores the most goals during the duration of the match (90 minutes) wins (Weil et al., 2023).

Figure 1 shows a general 4-4-2 formation (common in football) comprising of four defenders, four midfielders and two forwards (attacker). These position variations can be broken down further in to five sub-categories (not including the goalkeeper). They can be termed as central defenders, full-backs (defenders to the left and right of the central defenders), central midfielders, wide midfielders (midfielders to the left and right of the central midfielders) and attackers. Bradley et al. (2009) showed that the midfield positions covered a greater total distance (km) compared to the other playing positions. Wide midfielders covered greater high-intensity running (running speed >14.4 $km \cdot h^{-1}$) compared to all other positions and full-backs and wide midfielders covered greater distance at high speeds (19.8-25.1 $km \cdot h^{-1}$) in comparison to all other positions.

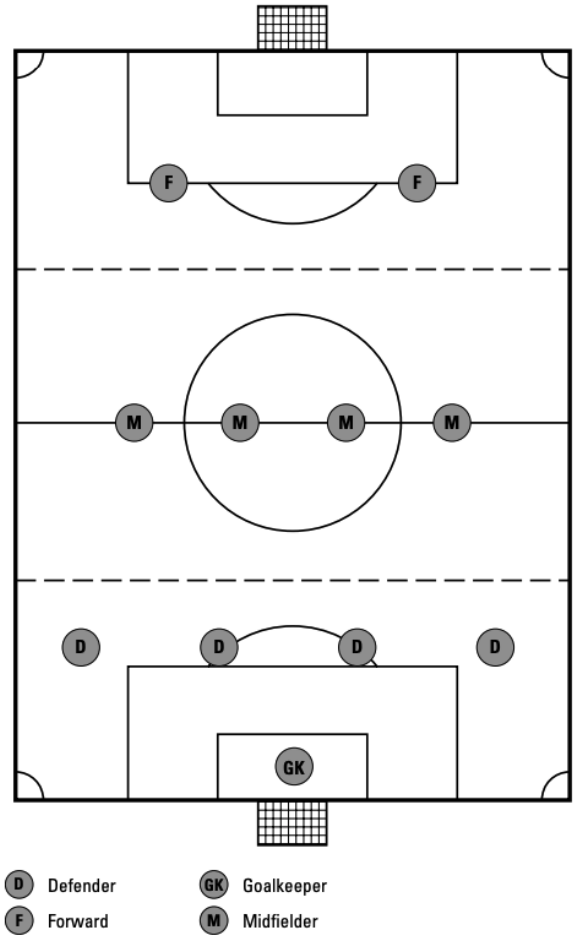

Figure 1. Outline of general playing positions in a 4-4-2 formation
(Long et al., 2011)

When football was originally created, players on a team were assigned a playing position dependent on their specific football skill or physical traits. Over the last 50 years, this idea has changed, especially after the success of the club team AFC Ajax and the Holland national team of the 1970s (Strudwick, 2016). This style of football, named 'total football', involved the players on a team adjusting and moving into the position of a team-mate if that player was drawn out of position during play. This system has led to the development of more well-rounded, high skill players that can comfortably carry out the roles of each position on the pitch competently. This 'total football' system can be seen not just as the catalyst for footballers becoming more competent at playing multiple positions in a football team, but also creating an upward shift in

footballers' athletic competencies and capacities to effectively carry out the physical demands of each position.

Wallace et al. (2014) investigated the evolution of game structure, speed and play patterns over a 44-year period and indicated that the physical demands of a football match have increased. The increase in player density (the number of players within a given area of the pitch at a given time), ball speed and passing rates underlined the importance of footballers becoming more effective at making split-second decisions and improving their physical performance characteristics.

Gender Differences

Interest in match performance characteristics in football matches has increased in the last decade due to the valuable information collected to help inform performance practitioners and coaches on areas for development. The relative physiological demands are similar between males and females (Krustrup et al., 2005), but females in elite competitive matches cover approximately 30% less high-intensity running (maximum speeds greater than 15km/h) in comparison to elite males, as well as spending more match play on low-intensity activities i.e., standing, walking, jogging (Andersson et al., 2010; Krustrup et al., 2005; Mohr et al., 2008). Milanović et al. (2017) highlighted that even though there has been a significant increase in football research in the last twenty years, there still exists a large disparity in the volume of studies involving male and female players.

Competition Standard Differences

It has been established that there is a clear difference in the physical demands between high competition level matches compared to other levels for both sexes (Gabbett et al., 2008; Krustrup et al., 2005; Mohr et al., 2008). Mohr et al. (2008) compared the work performed during matches in top-class females to high level female players and showed that top-class players covered more distance at high-intensities compared to high level players. Andersson (2010) showed that the same female players performed more high-intensity running in international matches compared

with domestic matches, whereas there were no differences observed in total distance covered and heart-rate response.

Athletic Performance Enhancement

The correlation between high levels of athleticism and superior performance has been consistently demonstrated in many team sports. Strength and power (Wisløff et al., 1998), speed (Little et al., 2005; Murphy et al., 2003), plyometric ability (Chimera et al., 2004; Rimmer et al., 2000) agility (Gambetta, 1990; Little et al., 2005), aerobic endurance (Castagna et al., 2006; Chamari et al., 2005; Hoff, 2005) and the ability to repeat high-intensity actions (Chaouachi et al., 2010; Little et al., 2005) have been identified as key determinants of high levels of sporting performance. These qualities have also been shown to reduce the risk of non-contact injuries (Chimera et al., 2004; De La Motte et al., 2017a; De La Motte et al., 2017b; Lehance et al., 2009; Malone et al., 2018; Malone et al., 2017b). These enhancements in an individual's athletic performance characteristics will not only improve their sporting performance to assist with gaining a competitive advantage over opponents but will also reduce injury risk. Time-loss injuries have been shown to be detrimental to sporting success (Hägglund et al., 2013; Raysmith et al., 2016) and will inevitably have a negative effect on an athlete's physical and sport specific skill development due to a reduction in training time. As a result, professional sports teams, national and international sporting organisations, and educational establishments have invested significantly in developing science and medical programmes to support the needs of their athletes and to ensure they are optimally prepared to compete and remain injury free.

Warm-Ups

The concept of 'warming-up' before sport has long been practiced and has generally been accepted in modern sporting environments by players and coaches as an important aspect of preparation for training and competition. The warm-up has commonly been based around the notion of acutely elevating an individual's body temperature (Asmussen et al., 1945) and cardiovascular activity (DeLorey et al., 2007; Robergs et al., 1991) to elicit a level of 'preparedness' to optimise upcoming performance in the following training session or

competition. These principles have long been researched, and the physiological changes are generally emphasised by coaches and sport scientists as some of the fundamentals to a successful warm-up. Jeffreys (2007) emphasised the importance of these principles being established as key to 'preparedness'. Individuals can expect positive effects on performance such as:

- Faster muscle contraction and relaxation of both agonist and antagonist muscles (Hoffman, 2014)
- Improvements in rate of force development (Asmussen et al., 1976)
- Improvements in reaction time (Asmussen et al., 1976)
- Improvements in strength and power (Bergh et al., 1979; Enoka, 2002)
- Lowered viscous resistance in muscles (Bishop, 2003; Enoka, 2002; Woods et al., 2007)
- Improved oxygen delivery to muscles (Ingjer et al., 1979)
- Increased blood flow to active muscles (Neiva et al., 2014)
- Enhanced metabolic reactions (Enoka, 2002; Zois et al., 2011)

Alongside these acute performance enhancements for the subsequent training session or match, well-structured warm-ups have been shown to reduce injuries (Barengo et al., 2014; Rokka, 2007; Safran et al., 1988).

Jeffreys (2019) highlighted that the warm-up should not only be seen as a performance enhancer for the upcoming session/match, but also as an opportunity to contribute to enhancing an athlete's athletic performance over the medium- and long-term time period. This can be done through developing certain athletic qualities that are highlighted as crucial to obtaining a competitive advantage over opposition. This could be through training change of direction/agility, speed, or plyometric ability. Faude et al. (2012) highlighted these skills as key differentiators to influence the outcome of a match. When looked at in terms of efficiency and effectiveness, a planned and structured warm-up can have a massive influence on an athlete's overall athletic development, primarily due to the accumulative time and repetitions spent honing these athletic qualities as mentioned above.

FIFA 11+ Warm-Up Programme

The FIFA 11+ was developed as a complete warm-up programme that requires minimum equipment (a set of cones and balls) and takes approximately 20 minutes to complete (Trajković et al., 2020). It is split up in to three parts, made up of running exercises at the beginning and end, and the middle part (part two), made up of specific preventive exercises focusing on strength, plyometrics and balance. These exercises each have three levels, increasing in difficulty, to provide variation and progression (Bizzini et al., 2013b).

There has been significant research on the success of the FIFA 11+ as an injury prevention programme (Sadigursky et al., 2017), and it has also been shown to enhance physical performance, specifically improvements in balance and stability, sprint, agility/change of direction (COD), and vertical jump performance (Ayala et al., 2017; Bizzini et al., 2013a; Impellizzeri et al., 2013). This information, alongside the research that showed the positive correlation between physical performance enhancement and injury prevention (Chimera et al., 2004; De La Motte et al., 2017a; De La Motte et al., 2017b; Lehance et al., 2009; Malone et al., 2018; Malone et al., 2017b), suggests that if the FIFA 11+ could be modified to further enhance some of these physical performance qualities, it could also be assumed that it would reduce injury risk further.

In 2016 the Accident Compensation Corporation (ACC), a New Zealand government run 24-hour no-fault insurance scheme that covers personal injury caused by accidents, invested heavily in the use of the FIFA 11+. It was rebranded the 'ACC SportSmart' warm-up and was promoted as a strength and conditioning warm-up to improve performance and keep athletes injury free (SportSmart, 2016). This initiative could be seen as an early-stage basic intervention targeted at participants with minimal to no training age and with similar goals to the comprehensive science and medical programmes previously mentioned.

Shamlaye et al. (2020) and Winstanley et al. (2023) investigated factors that may influence adherence to the FIFA 11+ by surveying football coaches in New Zealand. These studies

highlighted that shortening the warm-up, focus on performance enhancing effects, and an equivalent strategy to implement throughout a session, rather than being used as a stand-alone warm-up, would likely improve adherence. Whalan et al. (2020) suggested some strategies to overcome barriers to the FIFA 11+ adoption and adherence amongst players and coaches. Updating the current FIFA 11+ was one suggestion as it has remained 'untouched' since its 2009 launch despite recent research highlighting exercises and modes of delivery that could improve the efficacy of the programme. Another suggestion was the rescheduling of part 2 of the programme to an alternative time period as this strategy increased compliance, reduced severe injury incidence and burden, and addressed concerns associated with warm-up duration (Whalan et al., 2019b).

Significance of the research

Previous research suggests that athletic performance enhancement is linked to superior sport performance and reduction in injuries. Through evaluating the significance of a rescheduled modified FIFA 11+, and a rescheduled original FIFA 11+ on physical performance measures, the findings may be beneficial for the future implementation of national performance enhancement and injury prevention strategies in recreational footballers. The use of a cohort of recreational female footballers, who are significantly under-represented in comparison to male footballers in sports research, will also inform and guide practitioners working with female footballers to further develop the players they coach. Considering its inception was over 15 years ago there are very few studies that have looked specifically at modifications to the FIFA 11+. The findings from this study will encourage other researchers to investigate new innovations and/or additions to the FIFA 11+, or other physical performance enhancement programmes.

Purpose of the thesis

The overall purpose of this thesis was to determine if a rescheduled, modified FIFA 11+ part 2 would improve physical performance measures in female footballers in comparison to a rescheduled, original FIFA 11+ part 2. Previous research has suggested that a significant barrier to the implementation and compliance of the FIFA 11+ is the time taken to complete the three

parts at the beginning of a training session (Shamlaye et al., 2020; Winstanley et al., 2023). This would justify the rescheduling of the three parts of the FIFA 11+, which when done has been shown to maintain the FIFA 11+'s effectiveness at reducing player injury incidence and physical performance (Veith et al., 2021; Whalan et al., 2019b). The hypothesis was that the use of a modified, rescheduled FIFA 11+ as a football warm-up, and as a strength and conditioning programme for participants to follow would lead to greater improvements in physical performance measures compared to the original, rescheduled format of the FIFA 11+.

Structure of the thesis

Under the Auckland University of Technology's format 1, this thesis contains 6 chapters (Figure 2). Chapter 1 provides background, rationale, and significance to support the overall purpose of this thesis. Chapter 2 is a narrative review examining the current literature that has investigated the effect of the FIFA 11+ on measures of physical performance. Chapter 3 outlines the experimental design of the study, the interventions prescribed, and the procedures used in the testing process. Chapter 4 outlines the results of both the control (CON) and intervention (INT) groups and the differences between them. Chapter 5 and 6 discusses the key findings, and identifies the limitations of the thesis, and makes recommendations for future research, and provides suggestions for practical applications.

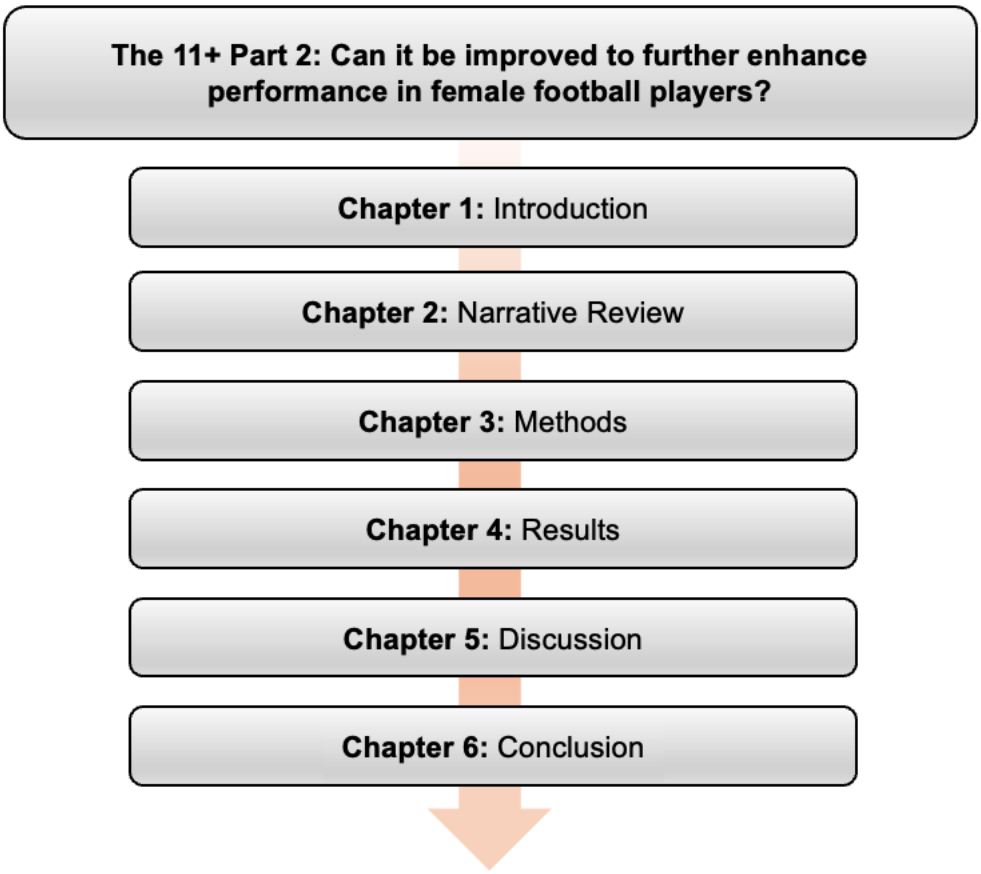

Figure 2. Overview of the thesis structure

Chapter 2: The Effect of the FIFA 11+ on Performance Measures: A Narrative Review

Introduction

In 1994 FIFA (International Federation of Association Football) created the Medical Assessment and Research Centre (F-MARC), made up of international experts in football medicine, to work independently as a research body. It's mission was to protect the health of all female and male football players, as well as promote football as a health-enhancing leisure activity (Dvorak, 2009). In 2006 F-MARC, together with the Oslo Sports Trauma Research Centre and the Santa Monica Orthopaedic and Sports Medicine Research Foundation, created the FIFA 11+, a neuromuscular warm-up programme designed to reduce injuries and enhance performance. The design was based on the experiences of previously investigated injury prevention and performance enhancement interventions, such as 'The 11', 'PEP' (Prevent Injury and Enhance Performance programme) (Gilchrist et al., 2008; Mandelbaum et al., 2005) and other exercise-based programmes (Caraffa et al., 1996; Heidt et al., 2000; Hewett et al., 1999; Soderman et al., 2000).

An early randomised control trial into the efficacy of the FIFA 11+ as an injury prevention tool showed that young female teams, performing the FIFA 11+ at least twice a week (as a standard warm-up before training), had 37% fewer training injuries and 29% fewer match injuries and severe injuries were reduced by almost 50% (Soligard et al., 2008). This study was used by FIFA in promotional resources provided to member associations during the FIFA 11+'s inception. Sadigursky et al. (2017) carried out a systematic review to evaluate the efficacy of the FIFA 11+ injury prevention programme for football players. Six studies were selected, including the Soligard et al. (2008) study, all of which were randomised control trials. The sample consisted of 6,344 players, comprising 3,307 (52%) in the intervention group (INT) and 3,3037 (48%) in the control group (CON). The review concluded the FIFA 11+ warm-up programme was effective for preventing injuries in soccer players of both sexes aged >13 years. However, it must be noted that the six studies reviewed compared the FIFA 11+ (INT) to regular football warm-ups (CON) which involved little to no exercise or drill prescription targeting the parameters that the FIFA

11+ targets, i.e., strength, balance. While the comparison between the FIFA 11+, an evidence-based intervention, and a regular football warm-up intervention utilising a selection of football specific skills involving a football at submaximal intensity is a fair reflection of real-life scenarios, there is also the need to compare the FIFA 11+ to neuromuscular warm-up programmes designed to target similar neuromuscular enhancements.

The merits of the FIFA 11+ as an injury prevention tool cannot be questioned (Sadigursky et al., 2017). However, what is less clear is whether the FIFA 11+ effectively enhance an individual's athletic qualities? The correlation between high levels of athletic qualities and superior performance has been consistently demonstrated in many team sports. For example, strength and power (Wisløff et al., 1998), speed (Little et al., 2005; Murphy et al., 2003), plyometric ability (Chimera et al., 2004; Rimmer et al., 2000) and change of direction (COD)/agility (Gambetta, 1990; Little et al., 2005), have been identified as key determinants of high levels of sporting performance. In football specifically, Faude et al. (2012) analysed the speed and power abilities for the assisting and the scoring player in the situations immediately preceding a goal. The observed actions were categorised as: no powerful action, rotation (around the body's centreline), straight sprint, change-in-direction sprint, jump, or a combination of these categories. Eighty-three percent of goals were preceded by at least one powerful action of the scoring or the assisting player. It was concluded that power and speed abilities are important in decisive football situations and, thus, should be included in fitness testing and training. These athletic qualities can also reduce the risk of non-contact injuries (Chimera et al., 2004; De La Motte et al., 2017a; De La Motte et al., 2017b; Lehance et al., 2009; Malone et al., 2018; Malone et al., 2017b). Enhancing athletic performance characteristics will not only improve a player's sporting performance to assist with gaining a competitive advantage over opponents but will also reduce injury risk (Chimera et al., 2004; De La Motte et al., 2017a; De La Motte et al., 2017b; Lehance et al., 2009; Malone et al., 2018; Malone et al., 2017b).

The FIFA 11+ is a well-researched injury prevention programme that has reported significant success in reducing injuries (Sadigursky et al., 2017). The purpose of this review was to

summarise the available literature to investigate the effect of the FIFA 11+ on the following performance measures; strength, speed, COD/agility, and jump height.

Methods

This review was conducted in accordance with published processes used to write a narrative review (Green et al., 2006). The decision to undertake a narrative review instead of a systematic review for the FIFA 11+ as a performance enhancement intervention was justified by several factors. Firstly, a narrative review allowed for the inclusion of diverse evidence types, accommodating the variety of studies using participants from sports other than football, and both sexes. Secondly, the exploratory nature of the research question was better suited for a narrative review, facilitating the identification of emerging themes. Finally, considering resource and time constraints, a narrative review provided a more feasible approach, allowing for a comprehensive examination of available evidence without the extensive requirements of a systematic review. An initial literature search was conducted in January 2022, with a secondary search conducted in January 2023, using the following databases: SportDiscus (EBSCOhost), Google Scholar, ScienceDirect and Ovid. Selected search terms and key words related to the FIFA 11+, strength, speed, agility, change of direction, plyometrics, jump height, and performance enhancement were combined using Boolean logic. Only full-text peer reviewed articles in English language were considered. Additionally, reference lists of selected articles were screened for other relevant articles. Only studies with physical performance measures measuring strength, speed, agility, change of direction, jump height, or plyometrics were included in the final review. The reporting of interventions used in the studies in the narrative review were termed INT for the FIFA 11+, or CON for the alternative intervention, unless stated otherwise.

Findings

Seventeen studies were identified as appropriate for inclusion in the review and all 17 were randomised control studies (RCTs). All studies published between 2013 and 2022 highlighting that the research investigating the efficacy of the FIFA 11+ as a physical performance enhancing programme is a current trend. There was a total of 719 participants, with a mean number of 42

participants, across the 17 studies. The largest study included 90 participants and the smallest study included 20 participants. Of the 719 participants, 118 (16%) were females and 601 were males (84%). The age range was 11-27 years with a mean age of 20 years. There were several different performance measures reported, six studies included strength measures, nine included speed measures, eight included agility/COD, and 10 included jump performance measures. Results of studies varied with some finding an improvement in physical performance with the implementation of the FIFA 11+ vs. regular football warm-up, while other studies found no effect. Fourteen of the studies reported some improvement in at least one of the physical performance measures in favour of the FIFA 11+, and three reported no significant difference in any performance measure between the FIFA 11+ and CON. A summary of the key characteristics of the included studies is presented in Table 1.

Table 1. Summary of the key characteristics of included studies

Author (year)	Study Design	Participants (analysed); gender; sport; age	Warm-up intervention vs. control; frequency; length; compliance (if stated)	Measures	Study Outcomes
Akbari et al. (2018)	RCT	n= 24; male, football 16.8 ±1.2 yr	FIFA 11+ vs. regular warm-up; 3x per week; 8 weeks	VJH	INT (between group): significant improvement in jump performance (p= 0.002)
Arede et al. (2022)	RCT	n= 30; male; football; 11.2 ±0.7 yr	Play-based tasks (INT) vs. FIFA 11+; 2x per week; 6 weeks	Sprint (20m); COD (The double 180° COD test)	INT: decrease in COD time and deficit between legs; FIFA 11+: decrease in sprint and COD time and deficit between legs.
Asgari et al. (2022)	RCT	n = 90; male; football; 17.0 ±0.7 yr (INT1); 17.0 ±0.7 yr (INT2); 16.7 ±0.6 yr (CON)	Modified FIFA 11+ (INT1) vs. FIFA 11+ (INT2) vs. routine warm-up (CON); 3x per week; 4 months	COD (Illinois agility test)	All groups improved pre- to post-test; INT1 improved significantly better than INT2 and CON; No significant difference between INT2 and CON
Ayala et al. (2017)	RCT	n= 21; male; football; 16.8 ±0.7 yr	FIFA 11+ (level 2) vs. normal warm-up; 3x per week; 4 weeks	Sprint (10 & 20m); VJH (DJ); COD (Illinois agility test)	INT (between group): 10 & 20m times decreased & VJH increased

da Costa et al. (2015)	RCT	n= 17; male; football; 18.3 ±1.6 yr	FIFA 11+ (week 1-3, level 1; week 4-6, level 2; week 7-9, level 3) vs normal warm-up; 3x per week; 9 weeks; 85% compliance	VJH (CMJ & SJ)	INT (between group): increase CMJ & SJ ($p \leq 0.01$)
Daneshjoo, Mokhtar et al. (2013)	RCT	n= 36; male; football; 18.9 ±1.4 yr	FIFA 11+ vs. regular warm-up; 3x per week; 8 weeks	Isokinetic knee strength: PT; con 60, 180 & 300°/s	INT (within group): increase ($p \leq 0.05$) ham PT; con 60, 180 & 300 (dominant); 60 & 180 (nondominant); INT (within group): increase ($p \leq 0.05$) quad PT; 300 (dominant); No changes in CON group; Con ham strength was significantly different between INT & CON; dominant ($p = 0.01$) & non-dominant ($p = 0.02$)
Dansehjoo,Rahnama et al. (2013)	RCT	n= 36; male; football; 18.9 ±1.4 yr	FIFA 11+ vs. regular warm-up; 3x per week; 8 weeks	Isokinetic knee strength: PT; con 30, 60 & 90°/s	INT (within group): increase ($p \leq 0.05$) ham PT; con 30 & 60 (dominant leg); 30 & 60 (non-dominant leg); INT (within group): increase ($p \leq 0.05$) quad PT; con 60 & 90 (dominant leg); 30, 60 & 90 (non-dominant leg)
Impellizzeri et al. (2013)	RCT	n= 81; male; football; 23.7 ±3.7 yr (INT); 23.2 ±3.8 yr (CON)	FIFA 11+ (week 1-3, level 1; week 4-6, level 2; week 7-9, level 3) vs. normal warm-up; 3x per week; 9 weeks	Sprint (20m); COD (T-Test); VJH (CMJ); Isokinetic knee strength: PT con 60 &180°/s; ecc 60°/s	Possibly meaningful (between group) increase in hamstring PT; ecc 60 & con 60 from a practical point of view; No significant difference for other measures

Lopes et al. (2019)	RCT	n= 71; male; futsal; 27.0 ±5.1 yr (INT); 26.0 ±5.1 yr (CON)	FIFA 11+ (4 weeks at level 3) vs. regular warm-up; 2x per week; 10 weeks	COD (T-Test); Sprint (30m); VJH (SJ)	No significant effect of the intervention was found for any of the performance measures between INT & CON groups
Lopes et al. (2020)	RCT	n= 71; male; futsal; 27.0 ±5.1 yr (INT); 26.0 ±5.1 yr (CON)	FIFA 11+ (4 weeks at level 3) vs. regular warm-up; 2x per week; 10 weeks	Isokinetic knee strength: PT con 60 & 230°/s; ecc 30°/s; H/Q strength ratio	No significant effect of the intervention was found for any of the performance measures between INT & CON groups in the short term; Ecc hamstring strength significantly higher in INT group in the long-term
Nawed et al. (2018)	RCT	n= 57; male; football; 20.6 ±2.1 yr	FIFA 11+ vs. regular training; 5x per week; 12 weeks	VJH (CMJ); Sprint (18.3m); COD (Illinois agility test & T-test)	INT (between group): VJH and 18.3m time significantly improved ($p \leq 0.05$); No significant difference in COD ($p \leq 0.05$)
Nuhmani (2020)	RCT	n= 59; female; basketball; 20.3 ±2.3 yr (INT); 20.2 ±2.1 yr (CON)	FIFA 11+ vs. regular warm-up; 3x per week; 12 weeks	VJH; Sprint (18.3m); COD (T-Test)	No significant effect of the intervention was found for any of the performance measures between INT & CON groups
Patti et al. (2022)	RCT	n= 29; female; futsal; 26.2 ±7.4 yr (INT); 26.8 ±6.5 yr (CON)	FIFA 11+ vs. Dynamic warm-up; 2x per week; 5 weeks	VJH (SJ); COD (Agility T-Test)	INT: increase in VJH ($p= 0.0024$); increase in COD ($p= 0.0077$)
Robles-Palazon et al. (2016)	RCT	n=21; male; football; 16.4 ±1.3 yr	FIFA 11+ vs. regular warm-up; 3x per week; 4 weeks	Sprint (10 & 20m); VJH (DJ)	No significant effect of the intervention was found for any of the performance measures between INT & CON groups

Kerman et al. (2018)	RCT	n= 30; female; football; 24.5 ±1.7 yr (INT); 24.3 ±1.4 yr (CON)	FIFA 11+ vs. regular warm-up; 3x per week; 8 weeks	Isometric knee strength (MVC) 90º flexion & extension	INT (between group): Significant increase in knee flexion and extension strength ($p \leq 0.05$)
Trajkovic et al. (2020)	RCT	n= 26; male; football; 11.2 ±0.8 yr(INT); 10.9 ±0.8 yr (CON)	FIFA 11+ vs. regular warm-up; 3x per week; 4 weeks	Sprint (20m); HJD (SLJ); COD (Illinois agility test)	INT (between group): Significant increase in SLJ ($p \leq 0.001$) and decrease in COD time ($p= 0.008$)
Zhou et al. (2022)	RCT	n= 20; male; football; 12.8 ±1.9 yr (INT); 13.3 ±0.2 yr (CON)	FIFA 11+ vs. typical warm-up; 3x per week; 8 weeks	Isometric knee strength (MVC) 90º flexion & extension; H/Q strength ratio; Sprint (30m)	INT knee flexor strength significant increase and significant decrease in extensor strength pre- to post-; CON no significant change; H/Q strength ratio significantly higher in in INT vs. CON; 30m time significantly better in INT vs. CON

INT= intervention group; CON= control group; RCT= randomised control trial; °/s= degrees per second; yr= years; ham= hamstrings; quad= quadriceps; H/Q= hamstring/quadricep; ext= extension; flex= flexion; con= concentric; ecc= eccentric; VJH= vertical jump height; DJ= drop jump; CMJ= countermovement jump; SJ= squat jump; HJD= horizontal jump distance; SLJ= single leg jump; MVC= maximal voluntary contraction; PT= peak torque

Strength

Six studies specifically investigated lower limb strength, particularly around the knee. Isokinetic knee strength has been measured in four studies with two of these studies looking at concentric strength (Daneshjoo et al., 2013; Daneshjoo et al., 2012) and two looking at both concentric and eccentric strength studies (Impellizzeri et al., 2013; Lopes et al., 2020). The remaining two studies looked at isometric strength (Kerman et al., 2018; Zhou et al., 2022).

Concentric quadriceps peak torque (PT) and concentric and eccentric hamstring PT has been reported to significantly increase within group after 8 weeks of performing the FIFA 11+ with a training frequency of three times per week over an eight-week period (Daneshjoo et al., 2013; Daneshjoo et al., 2012). It was also found that the FIFA 11+ improved concentric and eccentric hamstring PT, however from a performance perspective the increases were only possibly meaningful (<5% difference between INT and CON) (Impellizzeri et al., 2013). A significant improvement in hamstring to quadricep (H:Q) strength ratio has also been reported (Lopes et al., 2020). The studies that investigated isometric knee strength (Kerman et al., 2018; Zhou et al., 2022) both showed significant increases in strength measures in favour of the INT. The INT group in the study by Zhou et al. (2022) did show a significant decrease in knee extensor strength, but due to the increase in strength of the knee flexors, the H:Q ratio was significantly higher in the INT compared to the CON.

Five studies used adult male participants, with three studies in football (Daneshjoo et al., 2013; Daneshjoo et al., 2012; Impellizzeri et al., 2013), and one study in futsal (Lopes et al., 2020). One study used female participants from football (Kerman et al., 2018). All studies prescribed interventions for a minimum of eight weeks, with two studies running for nine weeks (Impellizzeri et al., 2013) and ten weeks (Lopes et al., 2020) respectively.

Overall, there is consistent evidence that suggests the FIFA 11+ enhances quadricep and hamstring strength. In all studies the CON intervention involved participants completing their

normal/regular training/warm-up with no consistent prescription of exercises or movements for the duration of the studies. The outcome from these studies is not surprising as there are exercises in the FIFA 11+ targeting the strengthening of the quadriceps and hamstrings, such as the squat exercise variations and the Nordic hamstring exercise. A limitation of the studies reviewed was that none recorded the compliance of participants to their respective intervention. This information would help determine the most effective dose to achieve a positive response and fundamentally highlight if the positive outcome in the studies, in favour of the FIFA 11+, was due to a discrepancy in training frequency between groups. There was also limited research using female participants which suggests that more research should be done using a female cohort.

Speed

Nine studies investigated speed over a variety of sprint distances, ranging from 10m up to 30m. Two studies measured sprint times over both 10m and 20m (Ayala et al., 2017; Robles Palazón et al., 2016), three studies measured sprint times for only 20m (Arede et al., 2022; Impellizzeri et al., 2013; Trajković et al., 2020), and two studies measured sprint times for 30m (Lopes et al., 2019; Zhou et al., 2022). Two studies measured sprint times at 18.3m, which corresponds to the studies' 20-yard sprint distance (Nawed et al., 2018; Nuhmani, 2020). Out of the nine studies, four reported the FIFA 11+ significantly improved sprint times over the respective testing distances (Arede et al., 2022; Ayala et al., 2017; Nawed et al., 2018; Zhou et al., 2022).

Arede et al. (2022) used a training frequency of two times per week over a six-week period and compared the FIFA 11+ to a play-based tasks intervention. The play-based tasks intervention was vastly different to the FIFA 11+ and consisted of four play-based tasks (five minutes per task) which aimed to develop dynamic stability, coordination, strength, plyometric ability, and speed/agility. The structure and the prescription of the tasks was significantly different to the modular structure of the FIFA 11+ and did not have any pre-prescribed sprint distance directive included in its programme. Ayala et al. (2017) compared the FIFA 11+ to a control group that used their usual warm-up, with a prescribed training frequency of three times per week for the duration of the 4-week study. The results showed that the FIFA 11+ had elicited substantial

improvements in 10m and 20m sprint times in comparison to the control group's usual warm-up routine. Nawed et al. (2018) compared an experimental group completing the FIFA 11+ and a control group continuing their regular warm-up, at a training frequency of five times per week. It was shown that the FIFA 11+ significantly improved their sprint performance over the 18.3m (20-yards) distance compared to the control group. Zhou et al. (2022) compared the FIFA 11+ to a CON group that completed their typical warm-up for the duration of the study (eight weeks) at the frequency of three times per week. The results showed that the post-test 30m sprint times of the INT players were significantly better than those of the CON players. It is worth noting that all four studies used male football participants.

Five studies reported no significant differences between the FIFA 11+ and a control group's intervention in their respective sprint tests (20m (Impellizzeri et al., 2013), 30m (Lopes et al., 2019), 18.3m (Nuhmani, 2020), 10m & 20m (Robles Palazón et al., 2016), and 20m (Trajković et al., 2020)). All these studies used footballers except Nuhmani (2020) and Lopes et al. (2019) who used basketball and futsal players, respectively. Additionally, Nuhmani (2020) is the only study that used a female cohort. As previously reported, research has shown that the exercises in the FIFA 11+, particularly exercises in part 2 that are categorised as strength exercises for the lower body, elicit strength increases. However, these exercises would best elicit adaptations in participants that have little, to no training age/experience and may not improve speed or more dynamic/explosive movements. The progressive overload of these movements is limited due to the lack of additional equipment in the FIFA 11+ and potential improvements in physical performance would dimmish quickly and plateau. One method of progressive overload when external resistance is not an option is to complete the prescribed movements with a greater velocity/tempo, particularly through the concentric phase of a movement. This can be used as a simple method of increasing an athlete's rate of force development (RFD) during a voluntary contraction when external resistance is absent (Young et al., 1993) and could enhance an athlete's rate coding (Enoka et al., 2017). Increases in rate coding is where the rate of neural impulses transmitted to the muscle fibres to generate force increases. These increases in motor unit firing frequency enhance the magnitude of the force generated by a muscle and the motor unit firing

rate of each motor unit increases with increasing muscular effort (rate coding) until the maximum rate is achieved. During these high speed muscle contractions, motor units firing at high frequencies will increase a muscle's RFD and has been shown to be achieved through high intensity training where the magnitude or velocity, or both, of a given load is moved maximally (the higher the load/velocity, the higher the intensity) (Zehr et al., 1994). The FIFA 11+ has no prescription of increasing execution speed for any exercises in the programme, including for progressions at level two or three. Part 2 does include jumping exercises, but it is clear the directives for execution at level one and two prioritise the quality of the landing rather than jump height or ground contact time. This pause for landing execution by participants would suggest minimal to no stimulation of the stretch shortening cycle (SSC) and could not be classified as a true plyometric exercise. This absence of a rapid pre-stretch (eccentric contraction) of the muscle and maximal effort through the concentric muscle contraction in level one and two of the jump aspect in part 2 of the FIFA 11+ means that they could not be considered a true plyometric exercise (Luebbers et al., 2003; Markovic, 2007).

Overall, there is conflicting evidence as to whether the FIFA 11+ is an effective intervention for developing speed. The studies that found no significant benefit of the FIFA 11+ were over a variety of timeframes, with two studies using a four-week training intervention (Robles Palazón et al., 2016; Trajković et al., 2020), and two studies using longer training interventions of nine (Impellizzeri et al., 2013) and 10 (Lopes et al., 2019) weeks, respectively. The studies that found a significant difference between groups, in favour of the FIFA 11+, were also over a variety of timeframes, ranging from four weeks to 12 weeks. There does not appear to be any consistent intervention period that optimally elicits an adaptation, if any, in speed performance. This would suggest that the performance increases found in the studies that reported a significant difference between groups may have been due to an external training stimulus and not due to the implementation of the FIFA 11+. The FIFA 11+ does not include any directed maximal sprint exposures or a very limited volume of explosive movements in any of the three parts. Due to the unpredictable and somewhat uncontrollable nature of sport specific training sessions there may have been situations where all participants, INT and CON, experienced significant high-speed or

maximal sprint exposures to elicit adaptations. The only way that this could be monitored effectively to compare between groups would be using global positioning system (GPS), and none of the studies included monitoring of any GPS running and COD metrics which may be why there is conflicting evidence on the programme's effectiveness in developing speed.

Agility and change of direction

Eight studies investigated the effect of the FIFA 11+ on COD/agility performance. Three different COD/agility tests were used in the eight studies with the T-test used in four (Impellizzeri et al., 2013; Lopes et al., 2019; Nuhmani, 2020; Patti et al., 2022), the Illinois agility test used in three (Ayala et al., 2017; Nawed et al., 2018; Trajković et al., 2020), and the double 180° COD test used in one (Arede et al., 2022).

Three studies reported the FIFA 11+ significantly improving COD/agility performance (Arede et al., 2022; Patti et al., 2022; Trajković et al., 2020). Arede et al. (2022) used cohort of male footballers and prescribed a training frequency of two times per week over a six-week period and compared the FIFA 11+ to a play-based tasks intervention. Trajković et al. (2020) also used male participants and compared the FIFA 11+ to a regular warm-up executed by the control group over four weeks with a training frequency of three times per week. Patti et al. (2022) prescribed female fustal players a training frequency of two times per week over a period of eight weeks for the two warm-up interventions, the FIFA 11+ and a dynamic warm-up. The dynamic warm-up consisted of running exercises, upper and lower limb mobility exercises, and a dynamic routine of high-knees, skips, butt-kicks, and grapevine exercises. This is the only study that included a prescribed warm-up for the CON group to follow for the duration of the study.

Five studies reported no significant differences between the FIFA 11+ and the other trial group's intervention in their respective COD/agility tests (Ayala et al., 2017; Impellizzeri et al., 2013; Lopes et al., 2019; Nawed et al., 2018; Nuhmani, 2020). All studies prescribed the FIFA 11+ as the INT and the respective footballer's regular warm-ups as the CON. One study used female participants (Nuhmani, 2020) and was also one of two, alongside Lopes et al. (2019), that used

participants from basketball, and futsal, respectively. Of the five studies only Ayala et al. (2017) used a training intervention period of four weeks, with the other studies (Impellizzeri et al., 2013; Lopes et al., 2019; Nawed et al., 2018; Nuhmani, 2020) using a training intervention between nine and 12 weeks.

The tests used in all studies included in the review could be better defined as COD tests due to participants running a pre-determined route. Agility has been defined as a 'rapid whole-body movement with change of velocity or direction in response to a stimulus' (Sheppard et al., 2006). The tests used do not involve the participants carrying out COD movements in response to a stimulus, and feature a relatively large amount of linear sprinting. Nimphius et al. (2018) critically evaluated the current measures of COD and agility. The T-test and Illinois test involve participants running a total distance of 36.6 metres and 60 metres, and require four and 11 changes of direction, respectively. The average time to complete these tests is 7.5-13 seconds for the T-test and 13-19 seconds for the Illinois test. Nimphius et al. (2018) highlighted that any single performance measure from an entire test that features a large amount of linear sprinting could mask COD performance (i.e., the athlete may be poor at making the COD but can recover through their superior linear speed). Young et al. (2001) proposed that linear speed training does not transfer to improving COD ability as they are considered separate physical/athletic qualities. The critical analysis of these COD/agility tests by Nimphius et al. (2018) showed that a specific COD/agility test should focus more on what happens during the COD, as opposed to the total duration of a test that predominately evaluates linear speed capacity. It is important to note that Arede et al. (2022) calculated the COD deficit for the right and left foot turns of the double 180° COD test which aligns to the recommended practical applications outlined by Nimphius et al. (2016). It was highlighted that the COD deficit may be a better tool to isolate and provide a more specific measure of an athlete's ability to change direction, in this instance at completing a 180° turn. The COD/agility tests in the studies included in the review all involve execution by participants at extremely high intensities, replicating some of the most demanding specific CODs in each study's given sport.

The FIFA 11+ does not involve any highly demanding COD, with only low intensity COD carried out after jogging no more than 10 metres. In studies that found significant improvements in COD/agility (Arede et al., 2022; Patti et al., 2022; Trajković et al., 2020) it is possible the improvements were due to training stimulus outside of the FIFA 11+. The coaching from the respective coaches used in the studies could have created situations where players involved were exposed to high intensity CODs in their respective sport specific training sessions. An example of this is rapid whole-body movements with change of velocity or direction in response to trying to win back possession from an opponent during a small sided game during a football drill. As previously mentioned, movements in part 2 of the FIFA 11+ use slower tempo movements with limited exposure to the velocities or loads an athlete would experience in their given sport during a match or competition. Another explanation for the significant improvements reported, especially in Trajković et al. (2020) with a short 4-week training intervention, is the potential low training age of the participants. Both studies used participants with an average age of 11.2 and 10.9 years old, respectively, and it is likely the participants had limited training experience for the exercises in part 2. This training age status would mean that any new training stimulus could cause an adaption at a rate that participants with a higher training age, or with a significant level of physical training experience, would not necessarily be able to achieve (Bompa et al., 2018; Selye, 1950).

Overall, there is conflicting evidence surrounding the effectiveness of the FIFA 11+ at enhancing COD/agility. The different study lengths suggests again there is no optimal intervention period to elicit adaptations, if any, and any positive changes in the respective studies may have been due to confounding factors, rather than the FIFA 11+'s effectiveness at enhancing physical performance. Further research into the effectiveness of the FIFA 11+ as a training intervention to develop COD ability is needed with a more specific testing protocol assessing isolated COD, i.e., 505 COD deficit (the time taken to turn is the direct measure rather than also including the time to linearly sprint in to and out of the turn being included). Again, females are underrepresented in the research.

Jump performance and Plyometrics

Ten studies included jump testing in their testing batteries. Vertical jump variations were used in nine studies (Akbari et al., 2018; Impellizzeri et al., 2013; Lopes et al., 2019; Lopes et al., 2020; Nawed et al., 2018; Nuhmani, 2020; Patti et al., 2022; Robles Palazón et al., 2016) and one study used a horizontal jump variation (Trajković et al., 2020).

Patti et al. (2022) and Lopes et al. (2019) both used the static/squat jump (SJ) as a vertical jump measure which is generally used to assess concentric-only jump performance due to the removal of the reactive SSC (McGuigan, 2019). This is generally executed by the participant holding a set squat position for 2-3 seconds. The SJ provides information about leg power performance (Anderson et al., 1993; Young, 1995). Patti et al. (2022) and Lopes et al. (2019) found that over an eight-week and 10-week training intervention period, respectively, the FIFA 11+ had a significant effect on jump height in comparison to the CON groups regular warm-up. Both studies used futsal players, with Lopes et al. (2019) using male participants and Patti et al. (2022) using females.

Nawed et al. (2018) and Impellizzeri et al. (2013) used the counter movement jump (CMJ) as the vertical jump test in their respective studies. The CMJ involves the participant performing a vertical jump by carrying out an eccentric movement followed by a rapid concentric movement. This process utilises the SSC and the jump height is generally higher than in other vertical jump variations due to the eccentric utilisation (Bobbert et al., 1996). Nawed et al. (2018) prescribed the training interventions for 12-weeks at a frequency of five times per week, with the CON completing regular training and the INT completing the FIFA 11+. Jump height significantly improved in favour of the INT. Impellizzeri et al. (2013) found no significant difference between the FIFA 11+ and the CON over nine weeks at a training frequency of three times per week.

da Costa Silva et al. (2015) used both the SJ and CMJ in their testing battery. It was found that the INT group that completed the FIFA 11+ at a training frequency of three times per week, for nine weeks, increased their jump height in both the SJ and CMJ significantly in comparison to

the CON group's normal warm-up. This is the only study included in the review that collected compliance data with all participants completing a minimum of 85% of the prescribed warm-up. The study's cohort were male footballers. The high compliance in this study was highlighted as being one of the primary reasons for the improvements seen in both the CON and INT groups.

Robles Palazón et al. (2016) utilised the drop jump (DJ) as the vertical jump variation in the study's testing battery for jump height. The DJ is usually used for measuring the reactive strength index (RSI) and the subjects ability to tolerate rapid SSC movements (Flanagan et al., 2008; McGuigan, 2019). In this case, jump height was the metric reported, with the results showing there was no meaningful difference between the FIFA 11+ (INT) and the regular warm-up (CON). It was highlighted that the duration of the study (four weeks) may not have created a significant enough stimulus to elicit chronic positive physical performance measures. A cohort of male footballers were used and the prescribed training frequency for both interventions was three times per week.

Standing long jump was the jump variation used by Trajković et al. (2020) in the study's testing battery. This jump variation is classified as a horizontal jump and can be deemed as being the most specific jump variation for athletic activities that work in the horizontal plane, such as sprinting (McGuigan, 2019). The four-week study used male footballers and involved a training frequency of three sessions a week for both the FIFA 11+ (INT) and the control group's regular training. The INT group significantly improved their jump distance in comparison to the CON.

Overall, there is conflicting evidence surrounding the effectiveness of the FIFA 11+ for enhancing jump performance. The studies included in the review have a wide variety of jump tests that measure jump height and jump distance. The outcome measures for each jump test are different and the studies included cannot be compared effectively. In each test, the jump variation's primary metric of interest to other practitioners may not be jump height or distance e.g., RSI in the DJ, and the use of these alternative metrics, if reported, could have helped to explain why certain changes in participants' performance may or may not have occurred. This would allow for a more

precise explanation regarding the success or failure of the prescribed intervention (Bishop et al., 2021), in this case the FIFA 11+.

FIFA 11+ Modifications

Finally, there have been few studies investigating how any modifications to the FIFA 11+ may impact performance benefits. The study by Asgari et al. (2022) investigated the efficacy of a modified version of the FIFA 11+ vs. original FIFA 11+ vs. CON that carried out its regular warm-up. The participants used were young male footballers. The intervention period lasted four months with all groups involved using a training frequency of three times per week, with the only performance test in the testing battery being the Illinois agility test assessing COD/agility performance. The modified FIFA 11+ consisted of four parts (seven, four, four, and five minutes in length) and the FIFA 11+ consisted of three parts. The first part of the modified FIFA 11+ included core exercises (prone, supine, and dynamic plank), balance exercises, and some strength exercises. The second part involved straight running, controlled contacts, hip-in and hip-out (with a higher frequency than the FIFA 11+), a dynamic stretch of hamstring with rotational, and cutting movements. The third part consisted of the Nordic hamstring exercise, single-leg standing with a heel-to-toe movement cycle (to optimize the stimulation of mechanoreceptors of the ankle) and throwing a ball to the partner simultaneously as well as squats (lunges, squat, and single-leg squat). The last part included agility and plyometric exercises, drop jumps, and countermovement jumps. The original FIFA 11+ involved a lot of the same exercises as the modified version, but the modified version had some additional and alternative exercises to the original and was scheduled slightly differently. The completion time for the modified FIFA 11+ of 21 minutes was similar to the guided length of the original FIFA 11+ (approximately 20 minutes).

The modified FIFA 11+ group showed significantly better performance improvements in the Illinois agility test compared to both the FIFA 11+ and CON groups, and there was no significant difference between the original FIFA 11+ group and the CON. Due to the extensive modifications and rescheduling of the modified FIFA 11+ it is hard to isolate which modifications had the greatest influence on the Illinois agility test performance. However, it is likely the inclusion of

more ‘true’ plyometric exercises in the modified FIFA 11+ were especially beneficial for running and COD performance (Asadi et al., 2016; Rimmer et al., 2000). A limitation of this study is again the use of the Illinois agility test as the Illinois agility test’s efficacy as an agility test has been questioned due to the lack of unpredictability and cognitive elements involved in its completion, as well as the significant number of linear sprints which can mask COD performance. Other COD tests should be considered that isolate the change in direction aspect of the test (Young et al., 2015). As the Illinois agility test was the only athletic performance test carried out in the study’s testing battery, there is the need to further investigate if these modifications to the FIFA 11+ can better enhance strength, speed, and jumping performance.

The limited number of research studies investigating modifications of the FIFA 11+ is surprising considering its creation was over 15 years ago. There have been significant developments surrounding the efficacy of certain exercises and actions for certain physical qualities (Harøy et al., 2019; Malone et al., 2018) during that time and it could be expected that if some of these changes were made it could improve the FIFA 11+’s effectiveness of improving some physical performance measures.

Conclusions and implications

The FIFA 11+ has been shown to be an effective injury prevention intervention, however there is conflicting evidence on its efficacy as an athletic performance enhancement intervention in comparison to regular sport warm-ups. Additionally, since its inception 17 years ago, most of the research has used male participants and very few studies have investigated alternative/modified versions of the FIFA 11+. Due to the amount of conflicting evidence for the FIFA 11+’s efficacy as a physical performance enhancement intervention further research into an alternate/modified version investigating its efficacy at enhancing physical performance measures such as strength, speed, COD/agility, and jump height is needed. Future studies should also look to include the most appropriate tests for assessing athletic performance that are most relevant to the sport in question and include females.

Chapter 3: Methods

Experimental Approach to the Problem

This study was a cluster randomised controlled trial conducted during pre-season training and the start of the 2022 football season in the region's top woman's football league. Participant teams were assigned to either the intervention or control group, and the selection of this allocation was randomised before baseline testing. Pre- and post-training intervention, participants performed strength (adductor strength test), speed (5m and 20m), COD/agility (505), and jump (jump height and reactive strength index) performance tests. Participants were familiarised with both the testing and training interventions before the experimentation. The training interventions were either a restructured format of the FIFA 11+ (CON) or a restructured modification of the FIFA 11+ (INT). Both interventions were split into two parts, a football warm-up done at the beginning of training sessions and matches, and a strength and conditioning programme done at a time point that practically suited the study's participants. Participants' compliance was recorded each week through an electronic survey collected at the end of each week.

Participants

Women's football clubs in the Wellington region were approached to participate in the study. Requirements for participation was for players to be between the ages of 16-35 years old, and to have been injury free for six months at the time of baseline testing. Participants were given an information sheet (Appendix E) as well as an oral presentation explaining the study process, their role in the process, and the significance of the research. Participants were encouraged to consult with parents, friends, and coaches before agreeing to participate in the study and were then were required to sign a consent form (Appendix F) if they agreed to participate.

Seven teams from the Wellington region agreed to participate in the study with a preliminary total of 100+ players expected to be involved. Due to the sudden outbreak of the COVID-19 virus, there was a hesitancy surrounding player health and safety, with three clubs withdrawing from participation. A significant portion of players from the remaining four teams also withdrew from participation with similar concerns.

Initially, 29 female participants were recruited to participate in this study. In total, 25 participants from 4 women's teams in the Wellington region, New Zealand, completed both pre-and post-testing and were included in the analysis. The 4 participants that did not complete post-testing were completing a 7-day isolation period due to the COVID-19 virus. Participants were recruited through the Capital Football Federation's senior women's leagues and a cluster randomised controlled design was used to minimise contamination bias within teams. Computer-generated randomisation was employed to ensure unbiased and systematic allocation of clusters which meant all players from one team were assigned to the same warm-up and training intervention. Participants were allocated to an intervention (INT: n= 13, age 24.9 ±4.0 years; height 164.9 ±5.8 cm; weight 68.1 ±8.0 kg) or control (CON: n= 12, age 20.1 ±4.6 years; height 165.1 ±4.6 cm; weight 62.4 ±9.0 kg) group.

All teams in the study were involved in pre-season training in preparation for the upcoming region's women's football season. All participants were healthy and free from injury at the time of data collection and attended football-specific training twice a week with two pre-season games in the final two weeks of the study period (duration the same for all participants). The age-range criteria outlined for participation in the study was 16-35 years old. Prior to participation, all participants and guardians were fully informed of the study procedures before giving their informed consent and assent. This study was approved by the University Ethics Committee (21/177).

Interventions

The INT group followed a rescheduled, modified FIFA 11+ programme, while the CON group followed a rescheduled, original FIFA 11+ programme. Both programmes involved the same part 1 and 3 from the original FIFA 11+ programme developed in 2009 (Bizzini et al., 2015). These parts involved jogging, dynamic running transition movements and sub-maximal sprinting, and were to be completed before football-specific training sessions (2x per week) and before matches (1x per week) (see Appendix A). This was assigned the name 'training/match day warm-up'. This training/match day warm-up took approximately 10-15 minutes to complete per session. Part 2, referred to as the 'strength and conditioning programme' (see Appendix B & C), was completed

at a time of each individual's choosing, e.g., before football-specific training, at home, and involved strength, plyometric and balance exercises that could be completed in limited space, with no additional equipment other than a football.

The CON group carried out the original part 2 from the FIFA 11+ made up of six exercises with three levels of difficulty (see Appendix B). The exercises included were 'the bench', 'sideways bench', Nordic hamstring curl (hamstring exercise), single leg stance, and squats. The 'bench exercises' involved the participants holding the truck part of the body in a straight line off the ground by supporting themselves on their forearms and toes of their feet. The 'sideways bench' was similar to 'the bench' but involved the participants turning their body 90º and supporting themselves on one forearm and on the side of one foot with the other foot stacked on top of the other. The Nordic hamstring curl involved the participants kneeling on the floor with their hips in full extension ensuring their body is completely straight from head to knees. With the support of a partner gripping the lower legs just above the ankle, the participant slowly leaned forwards to lower themselves to the ground by using their hamstrings to control the descent. The single leg stance exercises involved participants holding an athletic posture on one leg with a slight flex at the ankle, knee, and hip and maintaining balance. The squat exercises involved participants simultaneously flexing at the hips, knees and ankles until knees are flexed to 90º with a slight forward lean of the torso while ensuring they kept their back straight.

The INT group carried out a modified part 2 which was made up of 7 exercises with one level of progression (see Appendix C). The exercises included were 'the bench', glute hip thrust, adductor Copenhagen exercise, unilateral squat, bilateral squat, plyometrics, Nordic hamstring curl. 'The bench' and the Nordic hamstring curl exercises in the INT programme were the same as the CON groups' exercises. The glute hip thrust involved participants lying on their backs with their knees bent with feet hip-width apart. Driving through the heel and engaging the gluteal muscles, the hips raised off the floor into an extended position where the torso and the thighs created a straight line to the knees. The adductor Copenhagen exercise involved the participants lying with their

forearm used as support on the ground with their upper leg being held by a partner holding their leg with one hand supporting the ankle and the other hand above the knee. The participants then raised their hips off the floor and held a position where an imaginary line could be drawn through the mid-point of their body. The glute hip thrust and Copenhagen exercises were included to provide direct strengthening of the hip complex for participants as they challenged the musculature surrounding the hip in multiple planes of movement (Neto et al., 2019; Whalan et al., 2020). The unilateral squat involved the participant taking a foot position hip width apart ensuring toes were pointed straight ahead. A staggered stance position was then taken with one foot positioned in front of the body and the other behind. The participant would then descend to a point where the thigh was parallel to the floor and the rear leg's knee is just behind the hip. While maintaining balance, the participant would then push through the midfoot of the front foot to ascend back up and return to the starting position while continuously maintaining an erect torso. The bilateral squat involved participants placing their feet hip-width apart and taking an upright posture. The participant would begin the descent by simultaneous flexing at the ankle, knee, and hip while ensuring their knees did not buckle inwards. Once the knees reached 90º the participant would then return to the starting position by extending at the ankle, knee, and hip. The use of both squat variations, allocated separately (compared to the CON programme) in exercise slots in the strength and conditioning programme, created increased opportunities for participants to develop symmetry in strength and balance in both legs to enhance proprioception, joint and core stability, and develop their ability to effectively produce force on both legs and on one. The plyometric exercises involved the participants carrying out both the linear and lateral leaps in the same session ensuring ground contacts were on the balls of the feet and ground contacts were as explosive as possible. These exercises were the only exercises that involved both stage 1 and stage 2 to be completed in the same session and were not prescribed as progressions or regressions. These plyometric exercises involved both horizontal, lateral, and vertical force production compared to the CON plyometric exercises. It has been shown that including a variety of plyometric exercises induces greater performance improvements in sprinting compared to solely prescribing vertical or horizontal plyometric exercises in isolation (Ramírez-Campillo et al., 2015; Singh et al., 2013). The inclusion of this variety of plyometrics also aligns to the research

carried out by Brughelli et al. (2008) surrounding the positive influence on performance of exercises that closely mimic the demands of specific COD exercises. Further, these plyometric exercises, as well as the variety of other exercise modes (strength and stability exercises) in the INT programme have been shown to be crucial in reducing knee injuries in women, in particular anterior cruciate ligament (ACL) injuries (Sugimoto et al., 2015).

In both the CON and INT programmes participants would progress to the next level of difficulty once movement could be completed in the specified repetition range with an adequate level of competency. Throughout the study period the primary researcher consistently visited the football teams to give guidance to players on when to progress to the next level of exercises in the strength and conditioning programme. Re-ordering the parts of the FIFA 11+ has been recommended previously and has been shown to be successful (Veith et al., 2021; Whalan et al., 2019b). Whalan et al. (2019b) showed that rescheduling part 2 to the end of training sessions improved player compliance, and Veith et al. (2021) demonstrated that rescheduling part 2 outside of the training environment e.g., at home, elicited similar performance improvements to part 2 being carried out in the training session.

Testing Procedures

All testing was conducted during the pre-season phase at an indoor training facility on a hard indoor football surface. All participants were advised to wear general training shoes. The tests included the adductor squeeze test, 5, 10 and 20m straight line sprints (split times), 505 (change of direction speed) and jump performance (vertical and reactive strength index). All test protocols selected for this study have been used in previous research or are commonly used performance tests in football testing batteries (Bizzini et al., 2013a; Impellizzeri et al., 2013; Trajković et al., 2020; Turner et al., 2011; Walker et al., 2009). To ensure consistency, all testing protocols and instructions for all tests were administered by the same person at the pre- and post-testing stages of the study and standardised instructions and protocols were used for each test. Participants performed a standardised 10-minute warm-up that prepared them for the upcoming battery of

tests. The warm-up included dynamic stretching, linear running, COD and jumping exercises that replicated the movements the participants would be carrying out in the upcoming testing battery. After the warm-up three recorded trials were performed for each test. Before each test, participants went through a familiarisation protocol. The best performance for each test was used for analysis. Adequate inter-test intervals (30 seconds to three minutes) were included to ensure participants were fully recovered between trials. All tests were performed following a period of 24-48 hours of rest from physical activity to ensure participant readiness for testing was optimised (Ryan et al., 2019).

Adductor Squeeze Strength Test

Participants were positioned in a crook-lying position with a single pillow behind their lower back and arms folded across their chest. The participants hips were positioned in 45° flexion with knees flexed at 90° (Nevin et al., 2014). A sphygmomanometer (Delahunt et al., 2011) (Welch Allyn DS44, New York, USA), pre-inflated to 10mmHg, was placed between the participants knees. The participant was instructed to squeeze the cuff as hard as they could. The highest-pressure value displayed was then recorded and two minutes was allowed between each trial to ensure adequate recovery. The test was performed three times. Delahunt et al. (2011) showed that a commercially available sphygmomanometer was a reliable tool for assessing adductor squeeze values. The study indicated that 45° of hip flexion represented the optimal test position, with intrarater reliability (ICC value) of 0.92 (95% CI = 0.82, 0.97).

Linear Acceleration/Speed

Linear sprint times (s) were recorded at 5, 10, and 20m using electronic timing lights (D'Auria et al., 2006) (Smart Speed; Fusion Sport Pty, Ltd, Brisbane, Queensland, Australia) and measured to the nearest 0.01 seconds. 5m and 20m times were collected to measure participants' initial acceleration (early) and secondary acceleration (late), respectively, as recommended by Brown et al. (2004). The 10m time was measured to calculate the 505 COD deficit. Participants started in a two-point static stance (football-specific start position), 30cm behind the first timing lights, to

ensure no rocking prior to the start of the test. Participants carried out three trials that were separated by three minutes of recovery to ensure optimal performance for each trial. The use of electronic timing gates has been shown to have high reliability for measuring speed (coefficient of variation (CV)= 1%) (Waldron et al., 2011).

Change of direction

The 505 COD test was used as a measure of the participants' ability to change direction 180°, and was chosen due its football-specific replication of a footballer transitioning in general play from attack-to-defence, or vice versa. This specific COD test has been highlighted as a test that better isolates COD ability in comparison to some of the more frequently used COD/agility tests, such as the Illinois agility test and the T-test, which involve relatively large amounts of linear sprinting and multiple changes of direction (Nimphius et al., 2018). Participants started in a two-point static stance (football-specific start position), 30cm behind the start line, to ensure no rocking prior to the start of the test. Participants sprinted through the timing gates to the turning line, indicated by a line marked on the indoor training facility's floor, turning with their foot on or behind the line. Participants alternated turns off right and left foot for each trial. An assistant researcher was positioned in line with the turning line to ensure participants hit the turning line correctly and did not turn off the incorrect foot. If either happened, the trial was disregarded, and the participant reattempted after appropriate recovery time. Participants carried out six trials in total, with each trial separated by three minutes of recovery to ensure optimal performance. The test was recorded using electronic timing lights (Smart Speed; Fusion Sport Pty, Ltd, Brisbane, Queensland, Australia) and measured to the nearest 0.01seconds. The side with the fastest time was defined as the preferred side, whereas the other side was the nonpreferred side (Nimphius et al., 2016). Nimphius et al. (2016) also suggested that the COD deficit seems to provide a more isolated measure to better identify an athlete's ability to change direction due to reducing the effect of linear sprinting time within the 505 test. The COD deficit for the 505 for each leg was calculated using the formula: 505 time – 10m linear sprint time.

The use of electronic timing gates has been shown to have high reliability for this test (CV = 1% - 1.13%) (Waldron et al., 2011).

Vertical Jump Height

Unloaded CMJ were used to record vertical jump height (VJH). To assess participants performance, two separate FD4000 750mm x 250mm force plates (Vald Performance, Brisbane, Queensland, Australia) were used, one for each foot. The force plate data was collected and analysed using ForceDecks software (Vald Performance, Brisbane, Queensland, Australia) with all data collected at a sampling rate of 1000Hz. Force plates have been shown to be the 'gold-standard' for reliability for these tests (Sands et al., 2020). The participants were instructed to have their hands on their hips and squat down to a self-selected depth and jump as high and as fast as possible. The participants were advised that they must keep their hands on their hips throughout the full jump movement for the jump to be recorded. They completed two familiarisation practice jumps before completing three maximal effort CMJs, with approximately 30seconds rest between each jump. Jump height is determined by finding total flight time and using the following equation: jump height (JH) (cm) = ½ g $(t/2)^2$. g = 9.81m·sec^{-2} and t = time in the air (Moir, 2008). The CMJ has been shown to be an extremely reliable jump test in similar athletic populations (CV = 2.8%; ICC = 0.98) (Markovic et al., 2004).

Reactive Strength Index

Unloaded DJ were used to record RSI (Flanagan et al., 2008), an indicator of an athlete's ability to switch from an eccentric to a concentric contraction (Young, 1995). This is representative of the athlete's ability to utilise their SSC for dynamic and explosive movements. The participants were instructed to start by standing on a box set at a standardised height of 30cm and with hands on hips, facing towards the force plates. The participants were instructed to step out and off the box and then jump up as fast as possible after contact with the force plates to make sure their jump was the highest possible. The participants were advised they must maintain their hands on their hips throughout the full jump movement for the jump to be recorded. They completed two

familiarisation practice jumps before completing three maximal effort DJs, with approximately 30 seconds rest between each jump. RSI was determined by finding total flight time and ground contact time: JH (cm) / ground contact time (sec^{-2}). Flanagan et al. (2008) demonstrated the RSI to be a high reliable test, especially across multiple trials in team sport athletes (ICC = >0.95).

Compliance

During the study, participants were required to answer two multiple-choice questions at the end of each training week (Sunday) on their compliance to the assigned training programme. There were four multiple choice answers for both questions, 0, 1, 2, and 3. The application used was Microsoft Forms (Microsoft, Redmond, Washington, USA) and this was submitted to the lead investigator every Sunday throughout the intervention

The questions were as follows:

Question 1: How many times did you complete the football training/match day warm-up in the last week?

Question 2: How many times did you complete the strength and conditioning programme in the last week?

Statistical analysis

Statistical analysis was performed using the open-source software, JASP (Version 0.16.3). Descriptive statistics for the CON and INT groups were presented as means±standard deviation (SD). A 2-way repeated measures analysis of variance (RMANOVA) was selected to detect within groups (i.e., control and intervention) and between group differences (i.e., pre- and post-intervention), and whether a group×time effect was present, across the range of dependent variables (adductor squeeze strength, 5m sprint time, 20m sprint time, 505 COD deficit, VJH, RSI). The threshold for significance was set at $p \leq 0.05$ for all analyses.

While the data typically met the assumptions for the RMANOVA, several variables deviated from normality (e.g., detected via Q-Q plots and Shapiro-Wilk test scores, $p \leq 0.05$), and featured

outliers (preliminarily assessed via boxplots). In the former instance, this violation was judged permissible due to the relatively minor violations of normality (p= 0.04 to 0.02) and the relative robustness of the RMANOVA model. In the latter case, the outlier points were initially examined to ensure they were logical, and further classified using ±2SD cut-offs; of the few points that remained after further classification (adductor squeeze test, n= 2; 5m sprint time, n= 6; 20m sprint time, n= 3; 505 COD deficit preferred, n= 3; VJH, n= 3; RSI, n= 3), their practical influence on the result was judged to be null by comparing the impact of their removal on the outcome statistics with that of including them. For these reasons, all data was included in the final analyses.

Within the RMANOVA, attention was placed on the within-between interaction effect (i.e., group×time) to explore if there was a significant difference in the pre- and post- intervention change of each dependent variable by experimental groups (i.e., to determine it the impact of the warm-ups differed between CON and INT). The value of the F-statistic was also explored to check the equality of means between the two groups. Omega-squared (ω^2) and 95% confidence intervals (CI) were used to interpret the magnitude of effects within the RMANOVA model (time, group and group×time), with their qualitative magnitude assessed as $\omega^2 \leq$ 0.2 (trivial), 0.2-0.59 (small), 0.6-1.19 (moderate), 1.2-1.99 (large), ≥2.0 (very large).

Post-hoc analyses, using Holm's correction for multiple comparisons, were used to detect the magnitude of the pairwise differences of pre- to post-test scores, by group. Particular attention was placed on those outcomes for which it was established that there was an interaction effect. Differences in raw values were presented with their corresponding 95% CI alongside the respective p-values. Cohens d effect sizes (d) were used to interpret the magnitude of difference, with the following scale used to aid in interpretation: $d \leq$ 0.2 (trivial), 0.2-0.59 (small), 0.6-1.19 (moderate), 1.2-1.99 (large), ≥2.0 (very large) (Hopkins et al., 2009).

Chapter 4: Results

Compliance

The mean session compliance for the control group (CON) was 79.3% ±11.3 and 34.5% ±2.2 for the warm-up and S&C sessions respectively. The mean session compliance for the intervention group (INT) was 84.3% ±11.3 and 34.5% ±13.9 for the warm-up and S&C sessions respectively (Table 2).

Table 2. Mean session compliance percentages in CON and INT groups

	Control Group (N=12)		**Intervention Group (N=13)**	
	Warm-ups Completed	**S&C Sessions Completed**	**Warm-ups Completed**	**S&C Sessions Completed**
Mean	79.3%	34.5%	84.3%	45.3%
Std. Deviation	11.3	2.2	11.3	13.9

Within group differences

In the INT group there were significant changes in three of the performance tests (Table 3). In the 505 COD deficit preferred foot times there was a moderate increase in performance (d=1.29; ≤ 0.001) and in the 505 COD deficit non-preferred foot times there was a large increase in performance (d= 1.50; p≤ 0.001). There was a moderate increase in performance in the RSI (d= -0.74; p= 0.04) .

In the CON group there were significant changes in three of the performance tests. There was a moderate decrease in performance in the adductor strength measure (d= 0.70; p≤ 0.001), a moderate decrease in performance in the 5 m sprint time (d= -1.04; p= 0.01) and a small decrease in performance in 20 m sprint time (d= -0.59; p= 0.04) (Table 3). All within-group differences for both the INT and CON groups are graphically displayed in figures 3 and 4.

Table 3. Mean pre-post differences in CON and INT groups

	Control Group (N=12)			Post-hoc within-group		
	Pre	**Post**	**Difference**		**ES**	**ES qualitative**
	mean ±SD	**mean ±SD**	***mean + 95% CI***	***p***	**Cohen's d**	**descriptor**
Adductor Strength (mmHg)	145 ±19.66	130.33 ±16.29	-14.66 (-23.07; -6.26)	≤0.001	0.7	*moderate decrease*
5m (s)	1.12 ±0.07	1.19 ±0.10	0.07 (0.02; 0.13)	0.01	-1.04	*moderate increase*
20m (s)	3.51 ±0.14	3.60 ±0.16	0.09 (0.00; 0.17)	0.04	-0.59	*small increase*
505 COD Deficit Preferred (s)	0.65 ±0.07	0.72 ±0.14	0.07 (-0.10; 0.15)	0.06	-0.75	*moderate increase*
505 COD Deficit Non-Preferred (s)	0.70 ±0.08	0.67 ±0.08	-0.03 (-0.11; 0.05)	0.59	0.34	*small decrease*
CMJ Jump Height (cm)	23.58 ±3.47	24.14 ±4.03	0.56 (-1.60; 2.71)	0.50	-0.11	*trivial increase*
DJ RSI	0.72 ±0.21	0.75 ±0.31	0.03 (-0.24; 0.31)	0.72	-0.1	*trivial increase*

	Intervention Group (N=13)			Post-hoc within-group		
	Pre	**Post**	**Difference**		**ES**	**ES qualitative**
	mean ±SD	**mean ±SD**	**mean + 95% CI**	***p***	**Cohen's d**	**descriptor**
Adductor Strength (mmHg)	152.31 ±24.12	157.69 ±22.42	5.39 (-2.69; 13.46)	0.20	-0.26	*small increase*
5m (s)	1.13 ±0.05	1.14 ±0.06	0.01 (-0.04; 0.06)	1.00	-0.12	*trivial increase*
20m (s)	3.36 ±0.14	3.35 ±0.14	-0.01 (-0.09; 0.08)	0.85	0.37	*small decrease*
505 COD Deficit Preferred (s)	0.64 ±0.06	0.51 ±0.14	-0.12 (-0.20; -0.04)	≤0.001	1.29	*large decrease*
505 COD Deficit Non-Preferred (s)	0.72 ±0.10	0.57 ±0.13	-0.15 (-0.23; -0.07)	≤0.001	1.50	*large decrease*
CMJ Jump Height (cm)	29.34 ±6.16	30.19 ±6.58	0.85 (-1.23; 2.92)	0.50	-0.16	*trivial increase*
DJ RSI	1.02 ±0.30	1.28 ±0.50	0.26 (-0.01; 0.52)	0.04	-0.74	*moderate increase*

Values are mean ±SD; ES= effect size; CI= confidence interval; ES= effect size; COD= change of direction; CMJ= counter movement jump; DJ= drop jump; RSI= reactive strength index; ES Magnitude: d< 0.2 (trivial), 0.2-0.59 (small), 0.6-1.19 (moderate), 1.2-1.99 (large), >2.0 (very large)

Between group differences

There were statistically significant between-group differences in the pre-post change for five of the performance tests (Table 4). There was a trivial difference in four tests; the adductor strength (ω^2= 0.05*; p*≤ 0.001) in favour of the INT group, 5 m sprint time (ω^2= 0.04; *p*= 0.02) in favour of the INT group, 20m sprint time (ω^2= 0.02; *p*= 0.04) in favour of the INT group, and the 505 COD deficit non-preferred foot time (ω^2= 0.07; *p*= 0.01) in favour of the INT group. There was a small difference in one test; the 505 COD deficit preferred foot time (ω^2= 0.21; *p*≤ 0.001) in favour of the INT group. Changes in all other performance outcomes did not differ significantly between the two groups.

Table 4. Between group differences

	Analysis of Variance											
	Group				Time				Group × Time			
	F	***p***	***ω²***		***F***	***p***	***ω²***		***F***	***p***	***ω²***	
Adductor Strength (mmHg)	4.54	0.04	0.07	*trivial*	5.28	0.03	0.01	*trivial*	24.64	≤0.001	0.05	*trivial*
5m (s)	0.77	0.39	0.00	*trivial*	9.49	0.01	0.07	*trivial*	5.90	0.02	0.04	*trivial*
20m (s)	13.86	0.00	0.21	*small*	3.67	0.07	0.01	*trivial*	4.72	0.04	0.02	*trivial*
505 COD Deficit Preferred (s)	11.75	0.00	0.18	*trivial*	1.64	0.21	0.01	*trivial*	23.91	≤0.001	0.21	*small*
505 COD Deficit Non-Preferred (s)	1.27	0.27	0.01	*trivial*	23.62	≤0.001	0.18	*trivial*	9.34	0.01	0.07	*trivial*
CMJ Jump Height (cm)	8.25	0.01	0.13	*trivial*	1.84	0.19	0.00	*trivial*	0.08	0.78	0.00	*trivial*
DJ RSI	11.73	0.00	0.18	*trivial*	4.92	0.04	0.04	*trivial*	2.89	0.10	0.02	*trivial*

COD= change of direction; CMJ= counter movement jump; DJ= drop jump; RSI= reactive strength index; ω^2 Magnitude: < 0.2 (trivial), 0.2-0.59 (small), 0.6-1.19 (moderate), 1.2-1.99 (large), >2.0 (very large)

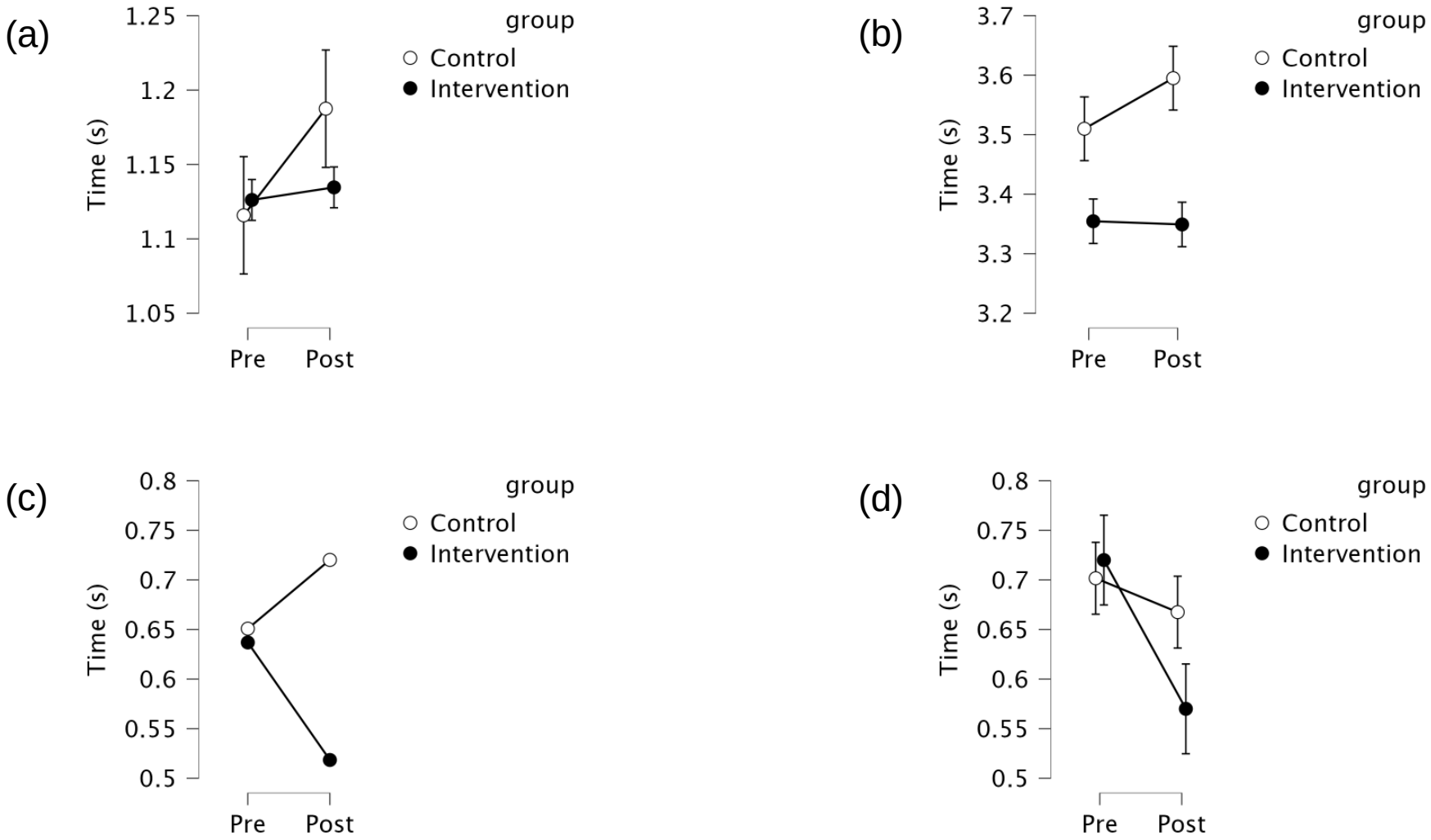

Figure 3. Pre- and Post- mean scores for CON and INT groups in running based performance measures (a) 5m sprint times; (b) 20m sprint time; (c) 505 COD deficit preferred foot time; (d) 505 COD deficit non-preferred foot time

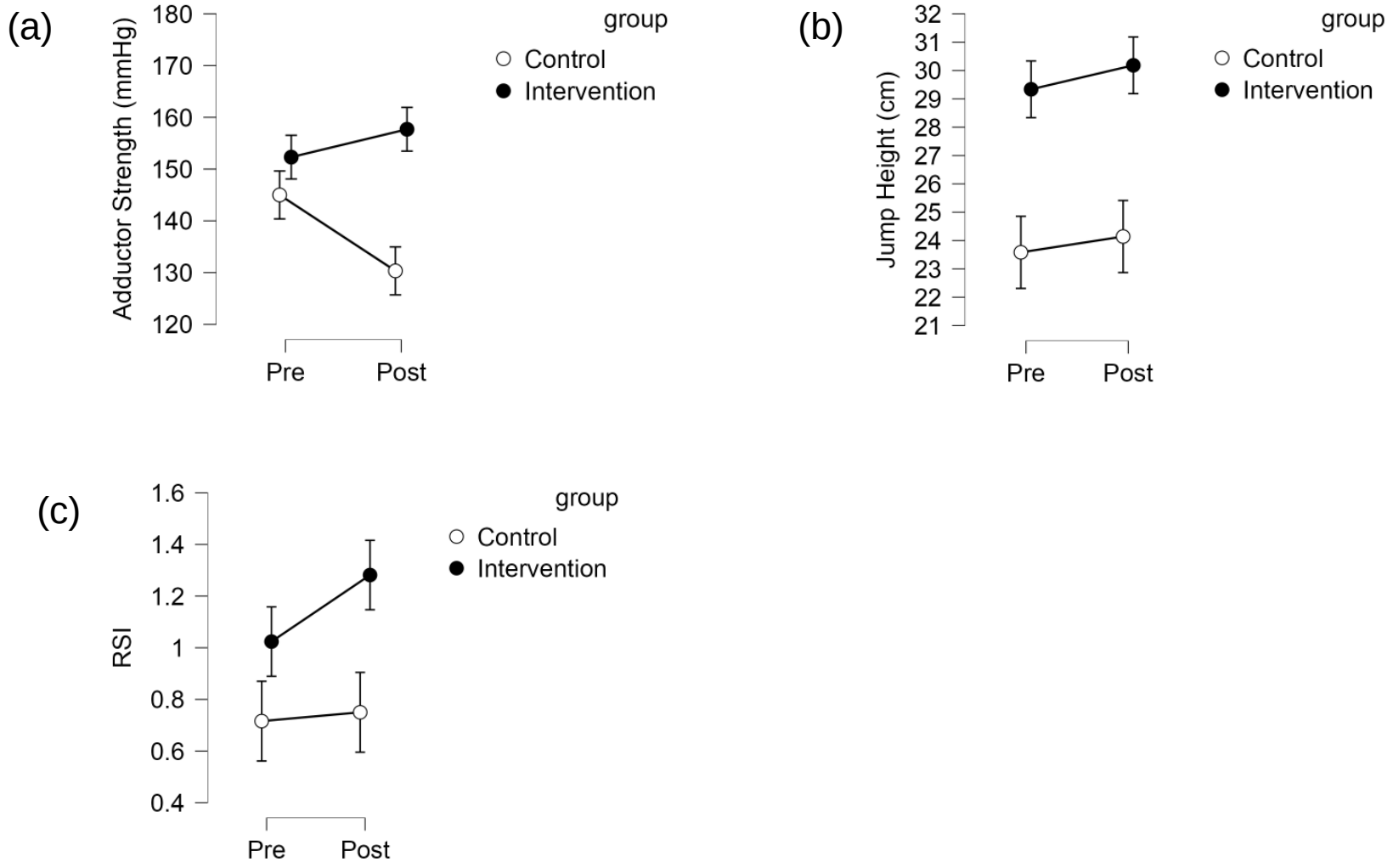

Figure 4. Pre- and Post- mean scores for CON and INT groups in non-running based performance measures (a) Adductor strength; (b) CMJ JH; (c) DJ RSI

Chapter 5: Discussion

This thesis aimed to determine if a modified part 2 of a rescheduled FIFA 11+ would improve physical performance measures in female footballers in comparison to a rescheduled original FIFA 11+ part 2. The main finding was that the modified, rescheduled FIFA 11+ programme was as effective at improving some specific physical performance measures in female footballers as the rescheduled, original FIFA 11+ programme. There was a statistically significant difference between the INT and CON pre-post change scores in five performance tests, in favour of the INT group in all five tests. The tests in question were the adductor strength test, 5m and 20m sprint times, and both the preferred foot and non-preferred foot 505 COD deficit times.

The adductor strength test showed a significant moderate decrease in the CON group ($d= 0.7$; $p\leq 0.001$), and no significant change in the INT group ($d= -0.26$; $p= 0.20$). It is likely the significant difference observed between groups ($p\leq 0.001$) was mostly due to a decrease in adductor strength in the CON. It must be noted that the between group difference in adductor strength was trivial ($\omega^2= 0.05$) and thus may not be practically meaningful. Whalan et al. (2020) highlighted the need for an exercise in the original FIFA 11+ targeting the hip and groin region, specifically the Copenhagen adduction exercise, due to the high prevalence of groin injuries in footballers (Whalan et al., 2019a). The Copenhagen adduction exercise was included exclusively in the INT group's strength and conditioning programme as it has been shown to be a highly effective exercise for strengthening the groin and hip region and reducing injuries in this area (Harøy et al., 2019; Harøy et al., 2017). This research would support the inclusion of the exercise in the INT programme, however the INT compliance in completing the strength and conditioning programme was low so at best it may be deemed as appropriate to maintain adductor strength.

Changes in sprint performance was significantly different between groups for the 5m ($p= 0.02$) and the 20m ($p= 0.04$), however the ES for both distances were trivial (5m, $\omega^2= 0.04$; 20m, $\omega^2= 0.02$) and consequently these differences are unlikely to be practically meaningful. The within-group sprint performances significantly decreased in the CON group (5m, $d= -1.04$; 20m, $d= -$

0.59) and remained unchanged in the INT group. Thus the significant between-group difference was likely due to a decrease in performance in the CON group.

Neither the INT or CON warm-up programmes involved exposures to maximal or near maximal velocity sprinting, with the highest directed running efforts being between 75-80% as directed in both programmes. It has been shown that frequent exposure to sprinting can improve sprinting kinetics and kinematics, and maximal sprint speed due to improve force generating capacity and greater lower extremity tendon stiffness (Talukdar et al., 2022). Exposure to maximal sprinting has also been shown to adequately prepare athletes for maximal velocity situations in match-play and also reduce injury risk (Malone et al., 2017a). Due to the absence of these running exposures, it is likely that the INT programme was more effective at maintaining participants initial acceleration (5m) and later stage acceleration (20m) through more effective strength and plyometric exercises compared to the CON programme. There are obvious limitations with both programmes due to the nature of the FIFA 11+'s guidelines of no specific equipment (e.g., resistance bands, dumbbells) being required to complete the three parts of the programme. This limitation creates a challenge in creating an appropriate stimulus to enhance performance capabilities. Progressive overload is a major component in ensuring continuous development in athletes (Pearson et al., 2000), and the use of equipment to create external resistance, such as the use of barbells and dumbbells for resistance training, is generally the primary method used in strength and conditioning to create progressive overload. In situations when using external resistance is not an option, there needs to be some modification to an exercise that can challenge the homeostatic status of an athlete. One method of progressive overload used in the INT programme was the emphasis on certain aspects of exercises being completed at higher intensity, such as the ascending ballistic movement of a squat jump. In comparison, the CON programme involved more controlled and slow tempo like-for-like movements, such as the squat with toe raise. The more intense, explosive movements in the INT programme should have a more significant effect on sprinting performance (Delecluse et al., 1995) by optimising more fast-twitch muscle fibre recruitment (Harris et al., 1994). This could explain why the INT group maintained initial acceleration (5m) and late acceleration (20m) qualities better than the CON group when

maximal and near maximal sprint exposures were absent in both programmes, however the significance of the decrease in times in the INT may not be practically meaningful.

Both programmes involved bounding which is a plyometric exercise highly specific to running performance (Rimmer et al., 2000). The INT S&C programme had plyometric exercises that require both vertical and horizontal propulsion when moving through the SSC, whereas the CON S&C programme involved more vertical propulsion. The lack of horizontal plane plyometric exercises in the CON S&C programme, alongside the lack of maximal or near-maximal sprinting exposures, may have caused the drop in performance in both the 5m and 20m sprint times. Ramírez-Campillo et al. (2015) and Singh et al. (2013) both highlighted that combining vertical and horizontal plyometric exercises is more advantageous to induce greater performance improvements in sprinting compared to solely prescribing vertical or horizontal plyometric exercises in isolation.

Results from previous research investigating the effectiveness of the FIFA 11+ as a performance enhancer for acceleration and speed is conflicting with several studies reporting no significant improvements when comparing the FIFA 11+ to a 'regular football warm-up' (Impellizzeri et al., 2013; Lopes et al., 2019; Nuhmani, 2020; Robles Palazón et al., 2016; Trajković et al., 2020). Nuhmani (2020) specifically used amateur female participants and found the FIFA 11+ should not be used as a training strategy to improve the sports performance parameters of sprint speed, agility, and vertical jump height. The intervention period prescribed to participants in this study was 12-weeks at a weekly training frequency of three times per week, which would suggest that the FIFA 11+ does not contain enough training stimulus to elicit changes in sprint performance.

In the 505 COD deficit preferred foot times there was a clear and large significant difference observed between groups ($p \leq 0.001$; $\omega^2 = 0.21$). The within group post-hoc analysis showed a moderate negative effect (increase in time) on performance in the CON group ($d = -0.75$; $p = 0.06$) and a large positive effect (reduction in time) on performance in the INT group ($d = 1.29$; $p \leq 0.001$). Thus it is likely the difference between groups is mostly due to the decrease in performance in the CON group and the increase in performance in the INT group.

In the 505 COD deficit non-preferred foot times there was also a clear difference between groups (d= 0.07; p= 0.01), however the ES was trivial (ω^2= 0.07) and thus may not be practically meaningful. Post-hoc analysis showed no significant changes in the CON times (d= 0.34; p= 0.59) and a large significant performance improvement (reduction in time) in the INT (d= 1.50; $p\leq$ 0.001). Thus, it is likely the difference between groups is due to the increase in COD performance by the INT in comparison to the CON.

The 505 COD deficit test has been highlighted as a test that better isolates and provides a more specific measure of an athlete's ability to change direction in comparison to some of the more frequently used COD/agility tests such as the Illinois agility test and the T-test (Nimphius et al., 2018). Previous research on the performance enhancement of COD/agility capabilities of the FIFA 11+ have primarily used the Illinois agility test and T-test (Ayala et al., 2017; Impellizzeri et al., 2013; Lopes et al., 2019; Nawed et al., 2018; Nuhmani, 2020; Patti et al., 2022; Trajković et al., 2020). The results observed in the CON group (original FIFA 11+) were consistent to past studies (Ayala et al., 2017; Impellizzeri et al., 2013; Lopes et al., 2019; Nawed et al., 2018; Nuhmani, 2020). Generally the durations of these studies were more than long enough (>9 weeks) for participants to develop an adaption as long as the individual session training stimulus was adequate enough to cause an adaptation (Cunanan et al., 2018; Selye, 1950). In these cases, the FIFA 11+ was either not a significant stimulus to cause an adaptation, or was inadequate at developing COD/agility.

The INT group's S&C programme included specific lateral plyometric exercises that could potentially explain the INT performance improvements in both tests (preferred and non-preferred foot) due to the nature of the 180º turn in the 505 COD test. Brughelli et al. (2008) highlighted the significance of exercises that closely mimic the demands of specific COD exercises and the positive influence these exercises could have on performance. This aligns with the theory of training transfer and the extent to which the training intervention in question affects sporting performance, or in this case influences performance in the 505 COD test (Issurin, 2013). Thomas et al. (2009) investigated the effect of plyometric exercises on agility in youth football players and utilised the 505 COD test. The study indicated that plyometric exercises (CMJ and DJ) could

improve footballer's agility and recommended the inclusion of these type of highly dynamic SSC exercises as part of football warm-up routines. The nature of the 'true' plyometric exercises prescribed in the INT programme that involve rapid pre-stretch (eccentric movement) of the muscle (Luebbers et al., 2003; Markovic, 2007) in comparison to the less dynamic jumping exercises in the CON programme, suggests the INT is more effective at developing COD/agility performance. Also as previously mentioned, the emphasis in the INT programme on explosiveness in certain movements compared to the CON programme may also have had an effect on the participants performance in the 505 COD test, especially in the exit from the 180º turn in the initial acceleration phase towards, and through, the timing gates at the 5 m mark. In a competitive football environment, these improvements in the INT group's COD/agility ability would mean they could potentially become better at evading opposition defenders when attacking and better at marking opposition attackers when defending. The speed at which modern day football is played also means that improvements in footballers COD/agility, specifically through 180º turn, would also have a positive influence on the effectiveness of a team's transition from attack to defence, or vice versa.

There was no significant difference between groups in the CMJ JH, however we did observe that the baseline performance in the INT was much better than in the CON group. In theory the INT group's adaptation potential would be lower than the CON due to their higher baseline score (Baker, 2013; Haff et al., 2015; Hoffman, 2014). Both the INT (*d*= -0.16) and CON (*d*= -0.11) improved their JH to a similar magnitude but due to the higher baseline in the INT, it could be suggested they would have diminished returns in comparison to the CON if both groups received the same training programmes with the same volume and intensity i.e. the same training stimulus. However, both groups received different programmes to follow for the length of the study, with the INT group following the modified FIFA 11+ and the CON following the original FIFA 11+. This would suggest that the S&C intervention prescribed in the INT programme was more effective at inducing performance increases in JH in the CMJ in comparison to the CON group. Impellizzeri et al. (2013), da Costa Silva et al. (2015), and (Nawed et al., 2018) all showed a significant difference in JH in the CMJ test in favour of the FIFA 11+ vs. regular warm-up. As

previously mentioned, the more intense and explosive movements in the INT programme would have a more significant effect on sprinting performance (Delecluse et al., 1995) by optimising fast-twitch muscle fibre recruitment (Harris et al., 1994). This could explain why the INT S&C programme may be more effective at developing jump performance compared to the already effective FIFA 11+.

There was no significant difference between groups in the RSI pre-post change scores, however the post-hoc analysis does show a moderate increase pre-post in the INT group (d= -0.74; p= 0.04) compared to no significant difference pre-post in the CON (d= -0.1; p= 0.72). This is a similar narrative to CMJ performance where the INT baseline performance was higher than in the CON so in theory it should have been harder to improve the groups baseline scores (Baker, 2013; Haff et al., 2015; Hoffman, 2014). The modified FIFA 11+ is potentially a more effective intervention at improving RSI performance compared to FIFA 11+. However further investigation using a larger sample size may give a more definitive answer as to whether the CON and INT programmes are effective at enhancing RSI performance. Healy et al. (2018) advised that implementing upper and/or lower contact time thresholds to accurately compare performance between RSI tests would help give a more definitive answer on whether there have been improvements in RSI performance. In this study there may have been a significant difference between groups if thresholds had been implemented in the testing procedure.

Compliance in both programmes was recorded by each individual participant in two parts, warm-ups completed, and S&C sessions completed. The warm-up was scheduled to be completed three times per week and was led by the coach. The S&C programmes were scheduled to be completed at a time that suited the participant with a minimum frequency of two times per week and a maximum frequency of three times per week. The INT group completed 84.3% of the scheduled warm-ups and 45.3% of the scheduled S&C sessions. The CON group completed 79.3% of the scheduled warm-ups and 34.5% of the scheduled S&C sessions. During the duration of the study, participants in both groups were impacted by the COVID-19 pandemic, whether that being through illness and/or restrictions implemented to restrict community transmission. This resulted in compliance in both groups being lower than the suggested frequency outlined at the beginning

of the study. As the S&C programme was self-directed rather than led by the team's coach, a high level of autonomy was required which may have impacted adherence. Veith et al. (2021) carried out a similar study using elite male youth academy footballers in an investigation on the rescheduling of the FIFA 11+ part 2 (S&C programme equivalent) being completed at home. The compliance for the home group was 87%. A possible reason for the low compliance in the current study compared to the Veith et al. (2021) study could be the recreational level of the footballers and the level of importance placed on completing the S&C part of the programme when competing with demanding everyday life challenges such as work commitments and family life. The reduction in performance in some of the performance tests in the CON was likely due to the dose-response effect (Busso, 2003; Calvert et al., 1976), with the CON training dosage not adequate enough to elicit a training effect. The INT group's compliance to the S&C programme is also low, however the volume and intensity experienced in each individual session completed may have been sufficient to develop the tested physical performance parameters. As the self-directed S&C components were to be completed during participants' personal time, it may not have been a priority due to other competing aspects of their everyday lives. The original guidelines for the FIFA 11+ were for all three parts to be completed in sequential order (Part 1>2>3). If the guidelines in this study had been to complete the football warm-up and the S&C component together at football training sessions, higher compliance may have been achieved due to the full programme being directly delivered by the football coach and completed in the team environment. Further research in to improving compliance of the FIFA 11+, or other modifications, is suggested as this is crucial to optimising the real-world effectiveness of the programme.

The results of this study have shown that the modified FIFA 11+ has some potential to enhance physical performance compared to the original FIFA 11+, however more research is needed. A larger sample size, and greater compliance from participants is needed to clarify whether or not the modified FIFA 11+ is more effective than the original FIFA 11+ at enhancing physical performance.

Chapter 6: Conclusion and Practical Applications

General Summary

In summary, this study provides some limited evidence that the implementation of a rescheduled, modified FIFA 11+ programme over an eight week intervention period is as effective at improving some specific physical performance measures in female footballers as a rescheduled, original FIFA 11+ programme. Players performing the modified FIFA 11+ programme (INT group) improved their agility/COD performance but did not significantly improve other physical performance characteristics (adductor strength, 5m and 20m sprint time, jump height, and reactive strength index). The differences between the groups were mostly trivial (except the small difference in 505 COD deficit preferred foot times) so were not considered practically meaningful. The compliance of participants in completing the warm-up aspect of each programme was adequate and met the guided weekly training frequency, however the compliance to the strength and conditioning programmes in both the control group (CON) and intervention group (INT) were low and may not have reached the minimum dose required to produce a training effect.

Limitations

There were limitations to this study that should be considered when interpreting the results. Three prospective teams declined the opportunity to be involved in the study in the week leading into the pre-testing battery due to the COVID-19 outbreak in New Zealand. Some players from teams that committed to full participation in the study also dropped-out due to hesitation surrounding the outbreak and potential transmission. These unanticipated drop-outs meant that the sample size was significantly smaller than originally planned and this could have increased the likelihood of type II error or failure to clearly show an effect when there may have been one.

Due to the nature of the study's self-directed strength and conditioning programme for both groups, the compliance was lower than the guided training frequency. This would have had a negative effect on the magnitude of the training effect for both groups and would suggest that if participants had completed the directed frequency, their physical performance could have improved more significantly.

Another limitation is that the participants menstrual cycle was not monitored. Monitoring each individual's menstrual cycle throughout the duration of the study may have given a better understanding of how their cycle affected their physical performance and psychological status, and testing and training could have been optimised to better obtain a greater adaptation. Research has shown that certain stages of the menstrual cycle, particularly the early follicular phase, can have a detrimental effect on exercise performance (McNulty et al., 2020) and monitoring could have helped the participants train more effectively around this phase.

Alongside the limitation regarding menstrual cycle monitoring, the lack of monitoring of the participants' other physical activity and training each week was also a limitation of the study. This means that we can't guarantee there was consistency of exposures to other training stimuli that could have affected the changes in performance measures.

Originally a strength test was proposed to be completed as part of the testing battery to investigate lower limb strength changes. The isometric mid-thigh pull was identified as the appropriate test to be used, however due to COVID-19 restrictions, the availability of a fixed bar rack was removed due to potential transmission at the training facility shared with other athletes and full-time professional sports teams.

Finally, the CON may not be seen as a 'true' control intervention due to the structure/schedule of the training warm-up and strength and conditioning programme in this study no longer replicating the original format of the FIFA 11+ that was developed in 2006.

Recommendations for further research

1. Additional research using a larger sample size would be recommended to establish if the modifications to part 2 elicit more significant performance increases compared to the original FIFA 11+ part 2.
2. Investigation in to the implementation of the modified part 2 to be completed in the same training session as part 1 and 3 on compliance and performance measures.
3. Investigation on the effect of the implementation of high speed running exposures in an appropriate slot in the running exercises of the FIFA 11+ on speed enhancement.

4. The effect of programme implementation by qualified strength and conditioning practitioners on physical performance parameters and movement competency compared to implementation by football/sport specific coaches.
5. Investigation on the effect of compliance through introducing a football in to the FIFA 11+, and making modifications accordingly to accommodate the football's introduction and the flow of the warm-up.
6. Suggested investigation in to modifying parts 1 and 3 with alternative running and movement exercises/drills.
7. Investigation in to the effects of the modified FIFA 11+ on participants with no training experience, and compare them to a group that have had some level of physical training experience e.g. ≥ 1 year of training experience.
8. Carry out testing at multiple time points throughout the season to assess progress of participants. This increased frequency of data collection would help determine if there are trends in physical performance enhancement or a point of diminishing returns/plateau.

Practical Applications

These results are relevant to football and other team-based sports. The study showed that completing the modified FIFA 11+ programme over an eight week period was as effective as the original FIFA 11+ at enhancing an individual's physical performance, however the results were not practically meaningful. Therefore, the following recommendations are suggested for football coaches:

- The modified FIFA 11+'s strength and conditioning programme could be used independently by recreational athletes in football or other team-based sports to assist with developing their physical performance if there is not an appropriate structured programme in place at their respective team/club.
- The nature of the modified FIFA 11+ programme covering the development of fundamental movements and skills, and the progressive intensity increase that elicits physiological preparedness makes it an appropriate programme to develop some baseline physical competency and general athletic proficiency specific to their sport.

- To maximise the programme's effectiveness for physical development, a training frequency of two times a week, minimum, is required to ensure enough training stimulus to obtain positive performance adaptations. Participants with a higher training age would benefit more from completing the programme three times a week and completing the higher level exercises as long as quality of movement is maintained.
- If possible, football clubs/teams should employ adequately qualified practitioners, such as strength and conditioning coaches and sport scientists. They can carry out the delivery of the warm-up and other conditioning aspects of the training session to ensure that all exercises are executed to the specified intensity and competency to enhance physical qualities in the players, but also reduce injury risk. The service provided by these practitioners can go further than just delivery of training sessions but also include continued advice on progressions and regressions, interventions to help athletes with their recovery and wellness, and to help drive compliance to prescribed interventions.
- Coaches should consider consistent performance testing of players to monitor the effectiveness of interventions prescribed. These tests should be used to help inform the coaches on areas of development for individuals, and the team as a whole. Messaging to players should also emphasise why these tests are being used and should help manage any potential anxiety that may arise.

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Appendices

Appendix A: Participant information page on structure and warm-up component for CON and INT groups

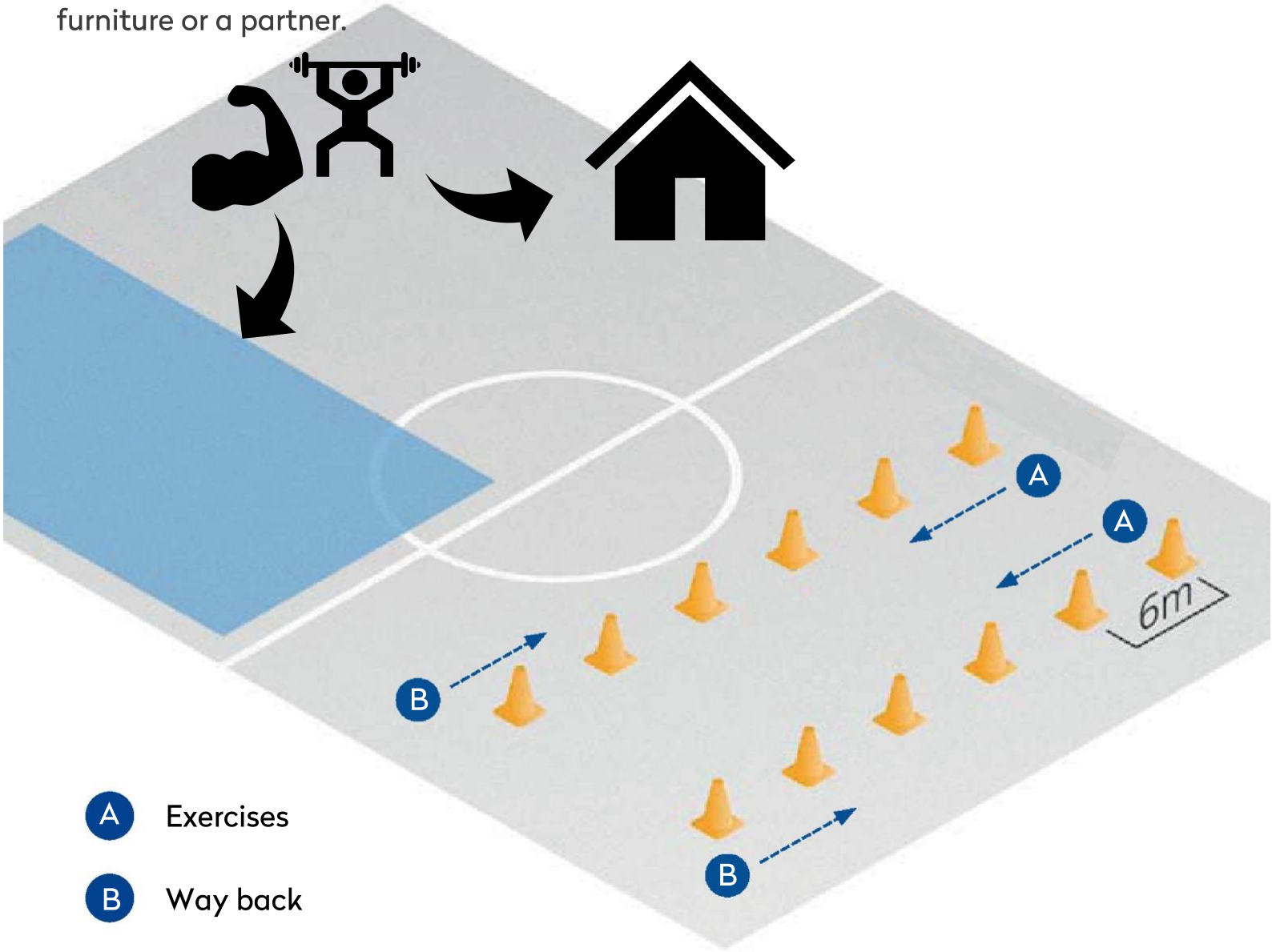
FOOTBALL WARM-UP AND S & C PROGRAMME

STRENGTH & CONDITIONING SET UP

The S&C programme is made up of exercises that will enhance physical performance and reduce injury. This programme can be completed before or after a training session on the football pitch, in the dressing room, at home or at another venue that conveniently works into your schedule. No specialist equipment is needed and will only involve assistance using a piece of furniture or a partner.

WARM-UP FIELD SET UP

The course is made up of six pairs of parallel cones, approximately 5–6m apart (30m in total). Two players start at the same time from the first pair of cones, jog along the inside of the cones and do the various exercises on the way. After the last cone, they run back along the outside. On the way back, speed can be increased progressively as players warm up.



FOOTBALL WARM-UP

The course is made up of six pairs of parallel cones, approximately 5–6m apart (30m in total). Two players start at the same time from the first pair of cones, jog along the inside of the cones and do the various exercises on the way. After the last cone, they run back along the outside. On the way back, speed can be increased progressively as players warm up.

The warm-up should be performed at the start of each training session and on match days, and will take between 10-12 minutes to complete. Key emphasis on the executing all movements to the highest quality and ensuring the intensity matches the demands of the training session or match.

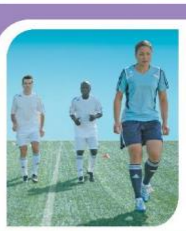
RUNNING **STRAIGHT AHEAD**
The course is made up of 6 to 10 pairs of parallel cones, approx. 5-6 metres apart. Two players start at the same time from the first pair of cones. Jog together all
the way to the last pair of cones. On the way back, you can increase your speed progressively as you warm up. **2 sets**

RUNNING **HIP OUT**
Walk or jog easily, stopping at each pair of cones to lift your knee and rotate your hip outwards. Alternate between left and right legs at successive cones. **2 sets.**

RUNNING **HIP IN**
Walk or jog easily, stopping at each pair of cones to lift your knee and rotate your hip inwards. Alternate between left and right legs at successive cones. **2 sets.**

RUNNING **CIRCLE PARTNER**
Run forwards as a pair to the first set of cones. Shuffle sideways by 90 degrees to meet in the middle. Shuffle an entire circle around one other and then return back to the cones. Repeat for each pair of cones. Remember to stay on your toes and keep your centre of gravity low by bending your hips and knees. **2 sets.**

RUNNING **SHOULDER CONTACT**
Run forwards in pairs to the first pair of cones. Shuffle sideways by 90 degrees to meet in the middle then jump sideways towards each other to make shoulder-to-shoulder contact.
Note: Make sure you land on both feet with your hips and knees bent. Do not let your knees buckle inwards. Make it a full jump and synchronize your timing with your team-mate as you jump and land. **2 sets**



RUNNING **QUICK FORWARDS & BACKWARDS**
As a pair, run quickly to the second set of cones then run backwards quickly to the first pair of cones keeping your hips and knees slightly bent. Keep repeating the drill, running two cones forwards and one cone backwards. Remember to take small, quick steps. **2 sets.**

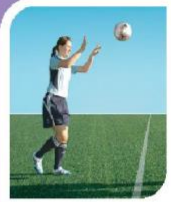
RUNNING **ACROSS THE PITCH**
Run across the pitch, from one side to the other, at 75-80% maximum pace. **2 sets.**

RUNNING **BOUNDING**
Run with high bounding steps with a high knee lift, landing gently on the ball of your foot. Use an exaggerated arm swing for each step (opposite arm and leg). Try not to let your leading leg toss the midline of your body or let your knees buckle inwards. Repeat the exercise until you reach the other side of the pitch, then jog back to recover. **2 sets.**

RUNNING **PLANT & CUT**
Jog 4-5 steps, then plant on the outside leg and cut to change direction. Accelerate and sprint 5-7 steps at high speed (80-90% maximum pace) before you decelerate and do a new plant & cut. Do not let your knee buckle inwards. Repeat the exercise until you reach the other side, then jog back. **2 sets.**

Appendix B: CON Strength and Conditioning component

S & C PROGRAMME

LEVEL 1	LEVEL 2	LEVEL 3
 THE BENCH STATIC Starting position: Lie an your front, supporting yourself on your forearms and feet. Your elbows should be directly under your shoulders. Exercise: Lift your body up, supported on your forearms, pull your stomach in, and hold the position for 20–30 sec. Your body should be in a straight line. Try not to sway or arch your back. 3 sets.	 THE BENCH ALTERNATE LEGS Starting position: Lie on your front, supporting yourself on your forearms and feet. Your elbows should be directly under your shoulders. Exercise: Lift your body up, supported on your forearms, and pull your stomach in. Lift each leg in turn, holding for a count of 2 sec. Continue for 40–60 sec. Your body should be in a straight line. Try not to sway or arch your back. 3 sets.	 THE BENCH ONE LEG LIFT AND HOLD Starting position: Lie on your front, supporting yourself on your forearms and feet. Your elbows should be directly under your shoulders. Exercise: Lift your body up, supported on your forearms, and pull your stomach in. Lift one leg about 10–15 centimetres off the ground, and hold the position for 20–30 sec. Your body should be straight. Do not let your opposite hip dip down and do not sway or arch your lower back. Take a short break, change legs and repeat. 3 sets.
 SIDEWAYS BENCH STATIC Starting position: Lie on your side with the knee of your lowermost leg bent to 90 degrees. Support your upper body by resting on your forearm and knee. The elbow of your supporting arm should be directly under your shoulder. Exercise: Lift your uppermost leg and hips until your shoulder, hip and knee are in a straight line. Hold the position for 20–30 sec. Take a short break, change sides and repeat. 3 sets on each side.	 SIDEWAYS BENCH RAISE & LOWER HIP Starting position: Lie on your side with both legs straight. Lean on your forearm and the side of your foot so that your body is in a straight line from shoulder to foot. The elbow of your supporting arm should be directly beneath your shoulder. Exercise: Lower your hip to the ground and raise it back up again. Repeat for 20–30 sec. Take a short break, change sides and repeat. 3 sets on each side.	 SIDEWAYS BENCH WITH LEG LIFT Starting position: Lie on your side with both legs straight. Lean on your forearm and the side of your foot so that your body is in a straight line from shoulder to foot. The elbow of your supporting arm should be directly beneath your shoulder. Exercise: Lift your uppermost leg up and slowly lower it down again. Repeat for 20–30 sec. Take a short break, change sides and repeat. 3 sets on each side.
 HAMSTRINGS BEGINNER Starting position: Kneel on a soft surface. Ask your partner to hold your ankles down firmly. Exercise: Your body should be completely straight from the shoulder to the knee throughout the exercise. Lean forward as far as you can, controlling the movement with your hamstrings and your gluteal muscles. When you can no longer hold the position, gently take your weight on your hands, falling into a push-up position. Complete a minimum of 3–5 repetitions and/or 60 sec. 1 set.	 HAMSTRINGS INTERMEDIATE Starting position: Kneel on a soft surface. Ask your partner to hold your ankles down firmly. Exercise: Your body should be completely straight from the shoulder to the knee throughout the exercise. Lean forward as far as you can, controlling the movement with your hamstrings and your gluteal muscles. When you can no longer hold the position, gently take your weight on your hands, falling into a push-up position. Complete a minimum of 7–10 repetitions and/or 60 sec. 1 set.	 HAMSTRINGS ADVANCED Starting position: Kneel on a soft surface. Ask your partner to hold your ankles down firmly. Exercise: Your body should be completely straight from the shoulder to the knee throughout the exercise. Lean forward as far as you can, controlling the movement with your hamstrings and your gluteal muscles. When you can no longer hold the position, gently take your weight on your hands, falling into a push-up position. Complete a minimum of 12–15 repetitions and/or 60 sec. 1 set.
 SINGLE-LEG STANCE HOLD THE BALL Starting position: Stand on one leg. Exercise: Balance on one leg whilst holding the ball with both hands. Keep your body weight on the ball of your foot. Remember: try not to let your knees buckle inwards. Hold for 30 sec. Change legs and repeat. The exercise can be made more difficult by passing the ball around your waist and/or under your other knee. 2 sets.	 SINGLE-LEG STANCE THROWING BALL WITH PARTNER Starting position: Stand 2–3 m apart from your partner, with each of you standing on one leg. Exercise: Keeping your balance, and with your stomach held in, throw the ball to one another. Keep your weight on the ball of your foot. Remember: keep your knee just slightly flexed and try not to let it buckle inwards. Keep going for 30 sec. Change legs and repeat. 2 sets.	 SINGLE-LEG STANCE TEST YOUR PARTNER Starting position: Stand on one leg opposite your partner and at arm's' length apart. Exercise: Whilst you both try to keep your balance, each of you in turn tries to push the other off balance in different directions. Try to keep your weight on the ball of your foot and prevent your knee from buckling inwards. Continue for 30 sec Change legs. 2 sets.
 SQUATS WITH TOE RAISE Starting position: Stand with your feet hip-width apart. Place your hands on your hips if you like. Exercise: Imagine that you are about to sit down on a chair. Perform squats by bending your hips and knees to 90 degrees. Do not let your knees buckle inwards. Descend slowly then straighten up more quickly. When your legs are completely straight, stand up on your toes then slowly lower down again. Repeat the exercise for 30 sec. 2 sets.	 SQUATS WALKING LUNGES Starting position: Stand with your feet hip-width apart. Place your hands on your hips if you like. Exercise: Lunge forward slowly at an even pace. As you lunge, bend your leading leg until your hip and knee are flexed to 90 degrees. Do not let your knee buckle inwards. Try to keep your upper body and hips steady. Lunge your way across the pitch (approx. 10 times on each leg) and then jog back. 2 sets.	 SQUATS ONE-LEG SQUATS Starting position: Stand on one leg, loosely holding onto your partner. Exercise: Slowly bend your knee as far as you can manage. Concentrate on preventing the knee from buckling inwards. Bend your knee slowly then straighten it slightly more quickly, keeping your hips and upper body in line. Repeat the exercise 10 times on each leg. 2 sets.
 JUMPING VERTICAL JUMPS Starting position: Stand with your feet hip-width apart. Place your hands on your hips if you like. Exercise: Imagine that you are about to sit down on a chair. Bend your legs slowly until your knees are flexed to approx.. 90 degrees, and hold for 2 sec. Do not let your knees buckle inwards. From the squat position, jump up as high as you can. Land softly on the balls of your feet with your hips and knees slightly bent. Repeat the exercise for 30 sec. 2 sets.	 JUMPING LATERAL JUMPS Starting position: Stand on one leg with your upper body bent slightly forwards from the waist, with knees and hips slightly bent. Exercise: Jump approx. 1 midways from the supporting leg on to the free leg. Land gently on the ball of your foot. Bend your hips and knees slightly as you land and do not let your knee buckle inward. Maintain your balance with each jump. Repeat the exercise for 30 sec. 2 sets.	 JUMPING BOX JUMPS Starting position: Stand with your feet hip-width apart. Imagine that there is a cross marked on the ground and you are standing in the middle of it. Exercise: Alternate between jumping forwards and backwards, from side to side, and diagonally across the cross. Jump as quickly and explosively as possible. Your knees and hips should be slightly bent. Land softly on the balls of your feet. Do not let your knees buckle inwards. Repeat the exercise for 30 sec. 2 sets.

Appendix C: INT Strength and Conditioning component

S & C PROGRAMME

STAGE 1

THE BENCH
STATIC
Starting position: Lie on your front, supporting yourself on your forearms and feet. Your elbows should be directly under your shoulders.
Exercise: Lift your body up, supported on your forearms, pull your stomach in, and hold the position for **30-60 sec**. Your body should be in a straight line. Try not to sway or arch your back and keep your hips level. **2 sets**.

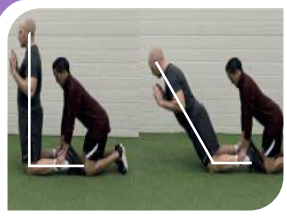
GLUTE HIP THRUST
TWO LEGS
Starting position: Lie on your back, position feet hip width apart. Feet should be positioned roughly a foot length away from your bottom. Use arms by your side to support shoulders.
Exercise: Drive your hips upwards by pushing through the heels of your feet and driving knees outwards. When at top of movement, squeeze bottom and hold for 2-3 seconds. Slowly lower to the floor and then repeat. **30-60 secs**. **2 sets**.

GROIN/ ADDUCTORS
ADDUCTOR COPENHAGEN EXERCISE-KNEE SUPPORT
Starting position: Lie on your side, supporting yourself on your forearm with your elbow directly under your shoulder. Partner using hands or knee , or if alone use a chair to support your leg just above the knee.
Exercise: Your torso should be completely straight with supported leg fully extended. Hold this position for the allotted time and change legs. If comfortable, slowly move the lower leg. Complete a minimum of **30-60 sec**. **2 sets**.

SINGLE LEG
FULL FOOT SPLIT SQUAT
Starting position: Take a half kneel position with one knee directly under hip and the front knee positioned directly over the top of the lowest part of your shoelaces.
Exercise: Push through the mid-foot of the front foot to extend front knee while maintaining upright torso. Do not let your knee buckle inwards. Descend until rear knee is nearly touching the ground, while still maintaining upright torso. Tempo is controlled .(approx. **10** times on each leg). **2 sets**.

TWO LEGS
BODYWEIGHT SQUAT
Starting position: Stand with your feet hip-width apart. Place your hands on your hips if you like.
Exercise: Imagine that you are about to sit down on a chair. Perform squats by bending your hips and knees to 90 degrees. Do not let your knees buckle inwards. Descend slowly then straighten up more quickly. Complete **10 reps**. **2 sets**.

PLYOMETRICS
LINEAR LEG EXCHANGE LEAPS
Exercise: A step-leap where the legs are staggered front-bank for a longer narrow base. While in the air, exchange front-back and alternate over the total reps or distance. Contacts should be on the balls of the feet. This can be done on the same spot if space is limited or while moving forwards over the set distance. Key coaching cues points are leaps for height, distance and fast ground contacts ('Ping'). Complete a minimum of **20** repetitions or **10-15 metres** while moving forward. **3 sets**.



HAMSTRINGS
NORDIC HAMSTRING LOWER
Starting position: Kneel on a soft surface. Use a partner or heavy object to fix your ankles down firmly.
Exercise: Your body should be completely straight from the shoulder to the knee throughout the exercise. Lean forward as far as you can, controlling the movement with your hamstrings and your gluteal muscles. When you can no longer hold the position, gently take your weight on your hands, falling into a push-up position. Complete a minimum of **3-5** repetitions and/ or 60 sec. **1 set.**

STAGE 2

THE BENCH
ALTERNATE LEGS
Starting position: Lie on your front, supporting yourself on your forearms and feet. Your elbows should be directly under your shoulders.
Exercise: Lift your body up, supported on your forearms, and pull your stomach in. Lift each leg in turn, holding for a count of 2 sec. Continue for **30-60 sec**. Your body should be in a straight line. Try not to sway or arch your back and keep your hips level. **2 sets**.

GLUTE HIP THRUST
SINGLE LEG
Starting position: Lie on your back, position feet hip width apart. Feet should be positioned roughly a foot length away from your bottom. Use arms by your side to support shoulders. Extend one leg while ensuring knees are the same height
Exercise: Drive your hips upwards by pushing through the heel of your foot and driving knees outwards. When at top of movement, squeeze bottom and hold for 2-3 seconds. Slowly lower to the floor. Alternate leg each rep **30-60 secs**. **2 sets**.

GROIN/ ADDUCTORS
ADDUCTOR COPENHAGEN EXERCISE-ANKLE SUPPORT
Starting position: Lie on your side, supporting yourself on your forearm with your elbow directly under your shoulder. Partner using hands or knee , or if alone use a chair to support your leg just above the ankle.
Exercise: Your torso should be completely straight with supported leg fully extended. Hold this position for the allotted time and change legs. If comfortable, slowly move the lower leg. Complete a minimum of **30-60 sec**. **2 sets**.

SINGLE LEG
BIG TOE SPLIT SQUAT
Starting position: Same as level 1 but front knee is positioned directly over the big toe. Raise heel off the floor and put weight through big toe.
Exercise: Push through the big toe of the front foot, while ensuring heel is off the floor, and extend the front knee while maintaining upright torso. Do not let your knee buckle inwards. Descend until rear knee is nearly touching the ground, while still maintaining upright torso. Tempo is controlled .(approx. **10** times on each leg). **2 sets**.

TWO LEGS
SQUAT JUMPS
Starting position: Stand with your feet hip-width apart. Place your hands on your hips if you like.
Exercise: Imagine that you are about to sit down on a chair. Bend your legs slowly until your knees are flexed to approx.. 90 degrees, and hold for 2 sec. Do not let your knees buckle inwards. From the squat position, jump up as high as you can. Land softly on the balls of your
feet with your hips and knees slightly bent. Complete **5 reps**. **3 sets**.

PLYOMETRICS
LATERAL: SIDEWAYS LEAPS
Exercise: A sideways leap where both feet, set at hip width apart, make contact with the ground at the same time. If space is limited, alternate direction of each leap. If using a set distance, complete distance leaping in one direction and then return back to start leaping the other direction. Key coaching cues are leaps for height, distance and fast ground contacts ('Ping'). Complete a minimum of **20** repetitions or **10-15 metres** while moving sideways. Complete moving in both directions to complete 1set . **3 sets**.

HAMSTRINGS
NORDIC HAMSTRING LOWER
Starting position: Kneel on a soft surface. Use a partner or heavy object to fix ankles down firmly.
Exercise: Your body should be completely straight from the shoulder to the knee throughout the exercise. Lean forward as far as you can, controlling the movement with your hamstrings and your gluteal muscles. When you can no longer hold the position, gently take your weight on your hands, falling into a push-up position. Complete a minimum of **6-10** repetitions and/ or 60 sec. **1 set.**

Auckland University of Technology Ethics Committee (AUTEC)

Auckland University of Technology
D-88, Private Bag 92006, Auckland 1142, NZ
T: +64 9 921 9999 ext. 8316
E: ethics@aut.ac.nz
www.aut.ac.nz/researchethics

6 July 2021

Michael McGuigan
Faculty of Health and Environmental Sciences

Dear Michael

Re Ethics Application: **21/177 The 11+ Part 2: Can it be improved to further enhance performance in female youth football players?**

Thank you for providing evidence as requested, which satisfies the points raised by the Auckland University of Technology Ethics Committee (AUTEC).

Your ethics application has been approved for three years until 6 July 2024.

Non-Standard Conditions of Approval

1. Edit the Information Sheet for coaches so that it uses the correct pronouns i.e. you for the coach and they for the participants.

Non-standard conditions must be completed before commencing your study. Non-standard conditions do not need to be submitted to or reviewed by AUTEC before commencing your study.

Standard Conditions of Approval

1. The research is to be undertaken in accordance with the Auckland University of Technology Code of Conduct for Research and as approved by AUTEC in this application.
2. A progress report is due annually on the anniversary of the approval date, using the EA2 form.
3. A final report is due at the expiration of the approval period, or, upon completion of project, using the EA3 form.
4. Any amendments to the project must be approved by AUTEC prior to being implemented. Amendments can be requested using the EA2 form.
5. Any serious or unexpected adverse events must be reported to AUTEC Secretariat as a matter of priority.
6. Any unforeseen events that might affect continued ethical acceptability of the project should also be reported to the AUTEC Secretariat as a matter of priority.
7. It is your responsibility to ensure that the spelling and grammar of documents being provided to participants or external organisations is of a high standard and that all the dates on the documents are updated.

AUTEC grants ethical approval only. You are responsible for obtaining management approval for access for your research from any institution or organisation at which your research is being conducted and you need to meet all ethical, legal, public health, and locality obligations or requirements for the jurisdictions in which the research is being undertaken.

Please quote the application number and title on all future correspondence related to this project.

For any enquiries please contact ethics@aut.ac.nz. The forms mentioned above are available online through http://www.aut.ac.nz/research/researchethics

(This is a computer-generated letter for which no signature is required)

The AUTEC Secretariat
Auckland University of Technology Ethics Committee

Cc: james.farr@nzfootball.co.nz

Participant Information Sheet

Date Information Sheet Produced:

30/06/2021

Project Title

The 11+ Part 2: Can it be improved to further enhance performance in female youth football players?

An Invitation

Hello, my name is James Farr and I am a player welfare officer for New Zealand Football. My primary duty in this role is to educate and assist clubs and players in different ways of preventing injury and enhancing performance. This research is for my Master of Philosophy thesis investigating enhancing athletic performance using an alternative format of the part 2 of the FIFA 11+ warm-up. I would like to invite you to take part in this research. You will not be individually identified in any of the results or outcomes from this research and your personal results will not be shared with any coaches from your club or given to any New Zealand Football national team selectors or federation talent and development selectors.

The intention of this study is to publish the research in an academic journal. As mentioned above, no identifiable information will be published in these journal articles and any individual results shown.

What is the purpose of this research?

The purpose of this research is to determine which format of part 2 of the FIFA 11+ has the most significant effect on athletic performance in female youth footballers. The results may benefit the well-being of footballers and develop football coaches' knowledge of training programmes. It may also help promote the warm-up programme in the New Zealand Football community and improve educational programmes for football coaches. The findings of this research may be used for academic publications and presentations.

How was I identified and why am I being invited to participate in this research?

You, alongside other female footballers, have been identified in the Wellington region to participate in this study. You fit into the age range that has been outlined (16-24 years of age) in the research proposal and your coach will have spoken to you about attending this meeting with myself to discuss this research and the part you could play in it.

How do I agree to participate in this research?

There is a consent form provided for you to sign, if you agree to participate in this research. I advise you to speak to your parents/guardians, partners and friends about this research before you sign the consent form.

Your participation in this research is voluntary (it is your choice) and whether or not you choose to participate will neither advantage nor disadvantage you. You are able to withdraw from the study at any time. If you choose to withdraw from the study, then you will be offered the choice between having any data that is identifiable as belonging to you removed or allowing it to continue to be used. However, once the findings have been produced, removal of your data may not be possible.

The coaches will be not be informed of results from any of the performance testing, so this will not affect any selection process throughout the football season. Other organisations such as New Zealand Football or Capital Football (Federation) will also not be informed of any individual results.

If you are suffering from heart disease, high blood pressure, any respiratory condition (mild asthma excluded), any illness or injury that impairs your physical performance you will not be able to participate in this study.

What will happen in this research?

This study will investigate what effect a modification of the FIFA 11+ part 2 warm-up has on athletic performance. Female community football players between the ages of 16-24 years old have been approached to be participants. You and the other participants will then be randomised into either the control group or the intervention group. Both groups will carry out the general part 1 and 3 of the FIFA 11+ at the beginning a football training session or a

match. These parts involve running, jumping and changes in direction at varying speeds covering a space of 30 metres x 5 metres. Completion of these two parts will ensure that you are physically prepared for the demands of the training session or match you are about to participate in. Part 1 and 3 will be termed as 'training and match day warm-up'. This warm-up should take no longer than 15 minutes to complete at the start of training sessions or matches.

The two variations of part 2 will be termed 'strength and conditioning' and will involve you completing a set of exercises made up of lower body strength, core and jumping exercises designed to improve your athletic physical performance and reduce injury. This should take no longer than 10-15 minutes to complete. You will be given the freedom to complete the strength and conditioning session at a time that suits your schedule and can be done at a variety of times and locations. Some examples are:

- before you take to the training pitch in the dressing room
- after a training session on the pitch
- in your living room at home
- during a break at work

Over the 8-week period of the study, you will be expected to undertake the training and match day warm-up before every football training session and match, and to complete the strength and conditioning session 3 times each week.

There will be continuous support from the primary researcher over the 8-week period of the study to further educate you and your coaches on the importance of quality of movement technique and to help with exercise progressions. You will be tested on a range of performance measures before and after the 8-week intervention period. The tests involved will be:

- 20 metre speed tests using speed gates will be performed twice. Times will be collected at 5 metre, 10 metre and 20 metre intervals. This will be repeated three times.
- A change of direction test, also using speed gates, that will involve running to a set line and turning 180 degrees. You will be required to complete this test three times by turning off both your right and left leg.
- Isometric mid-thigh pull using a fixed bar set in front of the thighs. This is performed using force plates and will involve you pulling as hard as possible on the fixed bar to exert force into the ground. The force plates will measure the force that you produce against them (see figure 1 below).
- Jump performance tests will be performed using force plates. These tests will involve you jumping as high as you can five times and will measure your jump height and explosiveness.
- A groin squeeze test using a pressure gauge positioned between the knees. This will show how strong the muscles in the groin region are (see figure 2 below).


Figure 1


Figure 2

The testing will take place at the Hurricanes Super Rugby training base, Rugby League Park, Newtown, Wellington, 6021.

What are the discomforts and risks?

Some of the physical movement tests you will carry out will require physical exertion, but should not place you under any major injury risk. These exercises and tests will involve movements that you typically perform as part of

your normal training and match play. You will be instructed on how to perform the testing movements correctly and safely by myself (an experienced strength and conditioning coach) and a warm-up will be provided before any testing takes place, to reduce any risk of injury.

How will these discomforts and risks be alleviated?

Myself, as the primary researcher, is first aid trained and will be present at all testing sessions.

What are the benefits?

You will have an opportunity to trial some performance tests that are commonly used in high-performance sport, that you wouldn't usually. This will allow you to experience some of the performance testing many of the top players in world football would undertake.

You will be able to ask the primary researcher what your personal scores/times are.

You will be coached on how to jump and land effectively and change direction safely with better technique. This could help improve your game and allow you to continue playing football/sport for longer.

What compensation is available for injury or negligence?

In the unlikely event of a physical injury as a result of your participation in this study, rehabilitation and compensation for injury by accident may be available from the Accident Compensation Corporation, providing the incident details satisfy the requirements of the law and the Corporation's regulations.

How will my privacy be protected?

The only personal information any of the research group will have is your name and date of birth and the only person who will see this information is the primary researcher. All other research assistants will only know you by an identification number and will have no access to your personal information. Your coaches and football clubs will know who is participating in the study but will not be given any information about your results. Any private information you have given me will be stored safely on a password protected hard drive, as per the university's policies.

What are the costs of participating in this research?

There is no financial cost to participate in this research. You will have to commit to 2 x 1 hour testing periods, 8 weeks apart and will be expected to carry out the FIFA 11+ warm-up protocol 2-3 times a week. This will take approximately 10-12 minutes to complete at the start of training sessions and matches, and 10 minutes in your own time away from the football pitch. In total, the protocols and testing will approximately take 8-12 hours to carry out over the 8-week period.

What opportunity do I have to consider this invitation?

You will be given up to a two-weeks after receiving the informed consent form to decide whether you wish to participate in the research. I will attend a club training session a second time to answer any questions and will collect consent forms at the first testing session. I advise you to speak to your parents to discuss this information sheet in more detail to potentially help inform you more before deciding on your participation in this study. You will also be able to contact me the primary researcher, if you have any questions or wish to send the form to me directly.

Will I receive feedback on the results of this research?

Yes, once the study has been completed and the data has been checked. I will provide you with your individual results and the general summary of the results for the whole study if you have ticked the appropriate areas of the consent form. Personal results will not be discussed as a group.

What do I do if I have concerns about this research?

Any concerns regarding the nature of this project should be notified in the first instance to the Project Supervisor, Professor Mike McGuigan, michael.mcguigan@aut.ac.nz , +64 9 921 9999 ext 7580

Concerns regarding the conduct of the research should be notified to the Executive Secretary of AUTEC, *ethics@aut.ac.nz* , (+649) 921 9999 ext 6038.

Whom do I contact for further information about this research?

Please keep this information sheet and a copy of the consent form for your future reference. You are also able to contact the research team as follows:

Researcher Contact Details:

Mr James Farr, james.farr@nzfootball.co.nz

Project Supervisor Contact Details:

Professor Mike McGuigan, michael.mcguigan@aut.ac.nz , +64 9 921 9999 ext 7580

Approved by the Auckland University of Technology Ethics Committee on 6 July 2021, AUTEC Reference number 21/177

Consent Form

Project title: ***The 11+ Part 2: Can it be improved to further enhance performance in female youth football players?***

Project Supervisor: ***Professor Mike McGuigan, michael.mcguigan@aut.ac.nz***

Researcher: ***James Farr, james.farr@nzfootball.co.nz***

- ○ I have read and understood the information provided about this research project in the Information Sheet dated 30/06/2021.
- ○ I have had an opportunity to ask questions and to have them answered.
- ○ I understand that taking part in this study is voluntary (my choice) and that I may withdraw from the study at any time without being disadvantaged in any way.
- ○ I understand that if I withdraw from the study then I will be offered the choice between having any data that is identifiable as belonging to me removed or allowing it to continue to be used. However, once the findings have been produced, removal of my data may not be possible.
- ○ I am not suffering from heart disease, high blood pressure, any respiratory condition (mild asthma excluded), any illness or injury that impairs my physical performance.
- ○ I agree to take part in this research.
- ○ I wish to receive a summary of the research findings (please tick one): Yes○ No○
- ○ I wish to receive a copy of my individual results (please tick one): Yes○ No○

Participant's signature: .....

Participant's name: .....

Participant's Contact Details (if appropriate):

.....

.....

.....

.....

Date:

Approved by the Auckland University of Technology Ethics Committee on 6 July 2021, AUTEC Reference number 21/177

Note: The Participant should retain a copy of this form.