Effectiveness of the FIFA 11+ Warm-Up in Improving Lower Extremity Biomechanics and Change of Direction Performance

Erin Cagle

Florida Southern College

HON 3956: Honors Proposal

Dr. Allen

April 24, 2022

Abstract

The prevention of anterior cruciate ligament (ACL) injury and the enhancement of sports performance are two common goals when working with athletes, and lower extremity biomechanics have been identified as modifiable factors for both. There is an abundance of research identifying the factors associated with ACL injury prevention and performance improvement, and there are various injury prevention programs (IPP) developed to correct faulty biomechanical movement patterns. While previous research has established the efficacy of these IPPs in reducing injury rates, it remains unclear if IPPs have positive effects on athletic performance. Specifically, there is little research that investigates the role of IPPs in improving the ability to perform a change of direction (COD) task. Therefore, the purpose of this study was to determine if participation in an IPP could reduce the rate of injury and improve the performance of a COD task. Twelve Division II collegiate, female soccer players participated in this study (six treatment, six control), with COD time and biomechanics, Landing Error Scoring System (LESS) assessment, and vertical jump ground reaction forces (GRFs) measured pre and post-intervention. Results found that there was a main effect for time across multiple variables and changes in left knee valgus angle in the control group from pre to post were statistically significant ($p=.034$). For all other variables, there was no significance across intervention or the combination of intervention and time. Therefore, further studies with larger samples should be conducted to improve understanding of the topic.

Chapter 1: Introduction

All sports have an inherent injury risk, and countless injuries can occur. However, based on data from the NCAA Injury Surveillance System, which collects injury data from collegiate sports teams, greater than fifty percent of all injuries sustained are to the lower extremity (10). Of these, it is also important to note that ankle ligament strains and anterior cruciate ligament (ACL) injuries made up the majority of this category, especially in women's soccer (10). Prevention of an ACL tear or strain is extremely important due to the long recovery times, high medical costs (8), and decreased performance associated with the treatment and rehabilitation of these injuries (19). There is also an increased focus on injury prevention in female populations because women are two to eight times more likely to tear their ACL than men due to inherent structural, hormonal, and neuromuscular differences between men and women (27). Consequently, injury prevention has become an increasingly important part of the sports medicine field and a major topic for research. Based on this research, specific programs and recommendations for injury prevention have been established (19).

Improvement of athletic performance is also a common goal in sports. Like ACL research, there has been a great deal of investigation into the role of biomechanics in the performance of sport-specific tasks like a change of direction (COD) in soccer. Existing research has attempted to identify the kinematic and kinetic factors that improve performance most during a COD (4,7,15). This review of the literature summarizes research analyzing the role of IPPs in modifying biomechanics to prevent injury and improve performance. Based on this review, we designed and implemented a research protocol aimed at addressing the lack of a clear relationship between IPPs and athletic performance outcomes.

Chapter 2: Review of Literature

Mechanisms of Anterior Cruciate Ligament Injury (ACL)

There are various risk factors, controllable and non-controllable that have been identified as playing a role in the chance of an athlete sustaining an ACL tear. Through retrospective studies, specific biomechanical movement patterns have been identified as modifiable risk factors for these injuries. Researchers have established four major mechanisms associated with an ACL tear (9). The first is a large knee valgus angle in which the knee goes inward, known as the ligament dominance theory. This occurs because the muscles do not absorb the ground reaction forces of the movement, so the ligaments of the knee must do so. Another mechanism is a small knee flexion angle, or not exhibiting enough bend at the knee while a task is performed. This generally occurs when athletes predominately use the quadriceps to stabilize the knee instead of the muscles of the posterior chain, like the hamstring causing them to be in an extended position. Therefore, this is known as the quadriceps dominance theory. The third most common mechanism is an imbalance in weight distribution between legs, also referred to as the leg dominance theory. This can occur within the nature of a task like COD in which all the weight is placed on one leg but could also be caused by asymmetries between an athlete’s legs. Finally, during injury, the trunk often has a lateral, or side, flexion that causes the center of mass to be outside the base of support. Athletes who lack control of their trunk commonly exhibit this mechanism known as the trunk dominance theory. Research by Pappas and colleagues (21) suggests that, although ACL injuries occur as a result of only one of the identified movement patterns being demonstrated, it is not uncommon for an athlete to exhibit more than one of these patterns at the time of injury. Sixty percent of the athletes in this research were placed in the high-risk category for ACL injury, and 46% of athletes exhibited more than one of the four common biomechanical movement patterns associated with this injury (21). Of the athletes that exhibited multiple faulty mechanisms, they showed a combination of the quadricep dominance theory and the leg dominance theory, or trunk dominance with leg and ligament dominance. When only one mechanism of injury was present, it was the ligament dominance theory of injury (21). This could be important to consider when implementing corrective exercises, as the practitioner may need to focus on more than one movement pattern to be effective.

Of these mechanisms of injury, there is research specifically focused on dynamic knee valgus, characterized by knee abduction. Researchers attempted to clarify the mechanics associated with this faulty movement pattern (12). In elite, female soccer players, there was a statistically significant relationship between initial knee abduction angle, lateral leg plant distance, and initial lateral trunk flexion and peak knee abduction moments during a 90-degree cutting task. When athletes performed this COD, as the distance between their COM and lateral leg plant increased, so did the peak knee abduction moment. Increased initial knee abduction angle and increased initial lateral trunk flexion also elicited a greater knee abduction angle in these athletes when they performed the COD task (12).

The speed at which an athlete performs a task is also associated with the biomechanical movement patterns exhibited. Research by Dai et al. (5) found that when athletes perform a 45-degree cutting task at maximal speed, which occurs very often within sports, knee extension moment, knee valgus angle, knee joint stiffness, and ground reaction forces increased while knee flexion range of motion decreased (5). All these mechanics are associated with a greater risk for ACL injury, suggesting that the demands under which a cutting task is performed play a role in the load on the ACL and biomechanical risk factors for injury (5). Based on these results, it is assumed that more ACL injuries may occur when an athlete is performing at maximal speed versus submaximal pace. Similarly, Vanrenterghem et al. (24) found a positive relationship between the approach speed when performing a 45-degree side-step and the peak knee valgus moment of the participants. As the athletes increased their approach speed, the peak knee valgus load experienced at this joint also increased (24). Based on these findings, it is important to ensure athletes use proper mechanics due to the number of high-speed COD they perform.

Injury Prevention Programs (IPP) and Biomechanical Modification

Because biomechanics, and specific movement patterns, have been identified as risk factors for sustaining an injury to the knee, many programs were developed to teach proper movement patterns, and potentially reduce the risk for injury. According to suggestions from the National Athletic Trainers' Association (NATA), injury prevention programs should incorporate a combination of exercises that have varying purposes including, but not limited to, strength, balance, agility, flexibility, plyometrics, and technique feedback (19). These programs either encompass the entire warm-up or are used in addition to a standard warm-up.

Several unique IPPs were used throughout the research in this review, and researchers examined the effects of each on varying performance tasks. Thompson et al. (23) utilized the F-MARC 11+ program and examined the effects of this IPP on biomechanics during a preplanned and unanticipated COD, a single-leg jump, and a double-leg jump. The F-MARC 11+ was implemented for 8 weeks and performed twice per week while the control group continued their standardized warm-up. Participants who received the F-MARC 11+ intervention improved their peak knee valgus moment during a double-legged jump from pre to post-intervention. During unanticipated cutting, the intervention group decreased peak ankle eversion angles. When performing the preplanned COD, single-leg jump, and double-leg jump peak eversion moments decreased in the intervention group. Additionally, the intervention group exhibited lesser peak knee valgus angle during unanticipated cutting after performing the F-MARC 11+ (23).

Another study, using the Core Position and Control (Core-PAC) warm-up, found that athletes participating in this warm-up versus the standard warm-up exhibited greater knee flexion angles during both a side-hop and a side-cut task. Pre-intervention and post-intervention data were collected for kinetic and kinematic data of a side-cutting task. The intervention group did not show any decrease in knee abduction moment (1). This indicates that the IPP was not successful in reducing all established mechanisms of ACL injury. In an earlier study, the same researchers measured kinetic and kinematic data of the side-cut after two variations of Core-PAC intervention. The data was first collected immediately after the first implementation of the Core-PAC intervention and the second data collection occurred after the 9-week implementation of the Core-PAC ended. At the first data collection, participants showed increased knee flexion angles, while also exhibiting lesser peak knee abduction moments. The second data collection had a greater variation across participants but overall showed that knee flexion angle also increased while knee abduction moment decreased (2). The variation between participants in the second data collection may be a result of the change in feedback between the intervention periods. During the first implementation of the Core-PAC, athletes received immediate feedback from a physiotherapist on how to fix their mechanics. When the program was implemented as part of the warm-up, the physiotherapist did not give the athletes any technique-based feedback. This type of instruction could only be given by the athlete’s training partner (2). It is important to note that the Core-PAC was a new IPP at the time of the research with no previous work prior (1,2). The results of the Celebrini et al. (2) initial study are in accordance with the NATA recommendations for an IPP (19). Their results showed that after initial feedback, athletes exhibited a more consistent improvement in their faulty biomechanical movement patterns. Although the intervention still saw improvements without the feedback, this indicates that for an IPP to be successful in modifying an athlete's movement patterns, they should incorporate an element of feedback on performance technique.

IPPs and Performance Improvement

IPPs were designed to reduce injury, so their effectiveness in improving athletic performance is unclear. Havens and Sigward (7) suggest that depending on the task, these programs do not create any improvement in performance. After evaluating the mechanics of two COD tasks and comparing them with those commonly linked to ACL injury risk, they concluded that the predictors for athletic performance were not always the same as predictors of ACL injury. This difference could cause IPPs to be ineffective in improving performance on tasks like a COD (7). Their results suggested that IPPs may only be successful in improving the performance of a 45-degree COD task, while IPPs do not appear to have an impact on performing a 90-degree COD (7).

Other researchers found similar results as well. In a study on the Santa Monica Prevent Injury Enhance Performance (PEP) program, researchers concluded that this IPP had no effect on improving an athlete's ability to perform a change of direction movement (25). The participants performed the PEP protocol for 12 weeks, with data collection occurring at week 6 and week 12. While this program was not successful in improving COD at either week 6 or week 12, it did create a positive effect on sprint-ability and countermovement jump performance. The changes seen in sprint-ability were not present at the final data collection. This suggests that even with tasks that IPPs improve acutely, there may be no long-term benefits to performance. Other research using an IPP similar to the PEP called Knäkontroll, which translates to Knee Control, found that after an 11-week intervention, female youth soccer players did not show improvements in performance measurements when compared with the control group that continued their normal warm-up without modification (14). In addition to countermovement jump, star excursion balance test, triple-hop jump, and sprint performance, one of the performance measures used in the assessment was a modified Illinois Agility test, which includes a change of direction at two points during the test. While this test did not specifically measure the performance of a single COD, the agility test can still be used to assess the ability to perform COD tasks (14).

Conversely, Zarei et al. (26) found that the FIFA 11+ IPP created significant improvements in several performance measures when compared to a control group who continued performing their normal warm-up routine. Like Lindblom et al. (14), this research included the Illinois Agility test in the performance testing. After thirty weeks of participation in the FIFA 11+ program as a warm-up for a minimum of two sessions per week, athletes exhibited a more significant decrease in their time to complete the Illinois Agility test than the control group. They were also able to improve sprint-ability and countermovement jump, which is consistent with other research results (14,26). The improvements seen in this study could be a result of the much longer time for IPP intervention. Additionally, while the Illinois Agility test does include a COD element, the cutting mechanism is not identical to the side-cutting COD used in other research. This could also be a cause of the variation in results between research studies. The researchers also implemented two different IPPs, which could also play a role in the conflicting results. The FIFA 11+ may be more useful in improving the performance of athletic tasks, specifically the COD, than other IPPs (14,26). Because of the disparity between the results of these studies, additional research should be performed to better understand the relationship between IPPs and performance enhancement, specifically, the performance of a COD task.

Biomechanical Characteristics of a Change of Direction Task

Within the sport of soccer, there are various movement tasks that can be measured to evaluate athletic performance, and similarly to injury risk, there are specific biomechanical characteristics associated with an athlete's performance of these movements. When evaluating athletes off the court or field, strength and conditioning coaches generally implement tasks such as a vertical jump or a COD task. Several authors focused on a COD, cutting task in their research, especially when the participants were soccer athletes (4,7,25). The purpose of many of these articles was to identify which biomechanical factors were most associated with faster COD times (4,7,15). According to research by Havens and Sigward (7), hip kinetics like extensor moment and medial-lateral center of mass separation are predictors for the performance of a 45-degree cutting task while medial-lateral ground reaction forces were predictors of performance of a 90-degree cutting task. Morrison et al. (16) also found that ground reaction forces were a determinant of faster change of direction; the ratio between horizontal and vertical GRFs may play an important role in improving speed during the transition phase of a COD task. The results of this study showed that when compared with vertical ground reaction forces, the horizontal ground reaction forces were greater when athletes performed better on the task. Change of center of mass (COM), through increased forward and lateral lean, has been associated with faster completion times of CODs (16). During a 75-degree cutting task, power and plantarflexion moment at the ankle were significant predictors of cutting time. When both of these biomechanical factors increased, the athletes were able to perform the COD task in a shorter amount of time (15). Additional predictors of performance in the 75-degree cut were pelvis lateral tilt, thorax lateral rotation, and total contact time. This variation in which kinetic or kinematic factor predicts greater performance could be due to the lack of similarity in cutting angle across the research.

Condello et al. (4), using a 60-degree cut, evaluated the differences in cut performance between male and female soccer players. The researchers found that men elicited greater medial-lateral ground reaction forces, which, as suggested by Havens and Sigward (7), is associated with greater performance of a cutting task. Female participants performed the cutting task at a smaller angle than the male athletes, and the researchers suggested this could also lead to better performance of these tasks (4). In addition to differences in the performance of cutting tasks based on sex, there was also a difference based on the leg being used. When athletes used their non-preferred leg to perform the cutting task, they were able to generate greater vertical ground reaction forces and perform the cutting task at a smaller angle (4).

These predictors were not the same as biomechanical predictors of knee injury risk during the same tasks, as discussed previously. While researchers did find that during a 45-degree cutting task, medial-lateral COM separation was a predictor of performance and knee abduction moment (a characteristic of dynamic knee valgus) (7), the other predictors of performance did not align with the previously established predictors of ACL injury risks. Jones et al. (12) also suggested that biomechanical changes associated with the reduction of ACL injury risk conflict with biomechanical factors that improve COD performance as measured by completion times. For example, greater lateral leg plant distance was associated with increased knee abduction moments (12). Because knee abduction moment is associated with dynamic knee valgus, it may be suggested to work on decreasing these distances to reduce injury risk. However, when the lateral leg plant distance is decreased, peak medial GRFs may also decrease

(12). This conflicts with research that indicates increased GRFs are associated with faster completion times of COD tasks (4,7,12).

Results of this research investigating the biomechanics that are associated with better performances on varying change of direction tasks could be useful in creating future IPPs. IPPs that target these biomechanical movement patterns, in addition to some of those established as mechanics for ACL injury, may be more successful in improving COD performance while still decreasing the risk for injury.

Conclusions

IPPs have been established as a means of reducing ACL injury, however, it is still unclear if these same programs can improve performance. Specifically, research on the role of IPPs in both reducing rates of injury and increasing performance during a cutting or change of direction task has not elicited any clear positive results (7,21,23). Much of the research on IPPs is focused on determining their efficacy as a tool to reduce the rate of injury and many do not measure variables of cutting performance like completion time. Only one study directly compared the biomechanics associated with performance to the biomechanics that predicted injury risk (7). There were also only two groups of researchers that directly investigated the role of an IPP in improving performance, and the results suggested that there was no significant effect on change of direction performance (14,25). Because of this, further research should be done to more clearly establish the efficacy of injury prevention programs to improve the ability of an athlete to perform a change of direction task. Results of further research into this relationship could have implications for future implementation and development of IPPs. The results could also provide greater motivation for coaches and trainers to include an IPP as a part of their warm-up programs.

Chapter 3: Methodology

Participants

Participants were gathered from the women's soccer team at Florida Southern College, a Division II institution. Prior to testing and intervention, written informed consent was received from nineteen participants. The exclusion criteria included current ACL injury or any injury that would prevent full participation in the program, and an inability to arrive approximately five to ten minutes early to the scheduled practice sessions. These participants were separated into an intervention and control group based on their ability to consistently attend the intervention sessions. Athletes unable to attend were placed in the control group. At the time of preintervention testing, the control group included nine participants and the intervention group included ten participants. Two participants dropped out prior to preintervention testing due to injury, and one participant was unable to complete postintervention testing due to injury (all from the control group.)

Preintervention Testing

Prior to beginning any testing, all participants provided their written informed consent after a full explanation of the testing and intervention protocols they would be participating in. After performing a dynamic warm-up, participants performed a drop vertical jump test and were scored based on the Landing Error Scoring System. The test followed a similar protocol to that established as a reliable test for assessing landing biomechanics by Padua et al. (20). Participants dropped horizontally off a box, onto a force plate. The participant then performed a vertical jump, shown in Figure 1, as soon as their feet hit the force plate. 2-D motion analysis cameras were set up to capture landing mechanics in the frontal and sagittal planes. The placement of the cameras and the force plate is shown in Figure 2. After performing a few practice attempts for familiarization, participants then performed two drop vertical jumps. Each jump was recorded, and raters watched the jump videos and scored each individual. Raters used the 17-point LESS scoring sheet to assess the number of biomechanical landing errors exhibited by a participant. The scoring sheet and defining criteria are provided in Figure 3. The scores for the two jumps were averaged to provide an overall LESS score.

Participants then performed a change of direction deficit assessment. This was determined by taking the time to complete a linear sprint and subtracting it from the time to complete a sprint with one change of direction. The CODD was taken using the 505 COD test. The participants performed a ten-meter linear sprint in which the athlete ran from the start line through timing gates placed ten meters from the start line. Participants continued to run through the ten-meter timing gates, to the turning line, and back through the timing gates. The turning line was placed five meters from the ten-meter timing gates. The setup of the timing gates is shown in Figure 4. Each participant performed one attempt for each foot with at least three minutes of rest time between attempts. The time for each foot was recorded. COD time for each foot was determined by subtracting the average ten-meter linear sprint time from the average 505 COD time. During the COD task, 2-D motion analysis cameras were set up to show the sagittal and frontal planes of the COD. One camera was placed in front of the turning point to capture the knee valgus angle in the frontal plane, while another was placed to the side of the turning line to capture the knee flexion angle in the sagittal plane.

Intervention

Athletes in the treatment group participated in the full FIFA 11+ (Appendix A) injury prevention protocol for a period of nine weeks. The intervention group arrived five minutes early to practice twice a week to complete this warm-up protocol. In total, athletes completed 18 intervention sessions. Prior to the first session, athletes in the treatment group were instructed on how to properly perform each movement in the warm-up. The FIFA 11+ warm-up includes eight minutes of running exercises, ten minutes of strength, plyometric, and balance exercises, and an additional two minutes of running exercises for a total of twenty minutes.

Throughout the intervention period, athletes in the control group continued to perform their standard warm-up protocol and continued the same sport and resistance training schedule as their teammates in the treatment group.

Postintervention Testing

The protocol for post-intervention L.E.S.S. and vertical jump testing was the same as the protocol used for preintervention testing. For the CODD test, the same protocol was used, but a different starting gate was used for the timing system. During preintervention testing, the Brower Smart Start was used, however, there were several complications with activating the timer. For this reason, a Brower Photogate was used as the start during postintervention testing. In the Brower Timing System Manual, the manufacturer states there is a potential difference in sprint times by .04 and .06 seconds with times recorded with the Smart Start being faster than those recorded with the Photogate (28). The correction factor was applied to the CODD times prior to running data analysis.

Data Analysis

Landing Error Scoring System scores and peak vertical group reaction forces were taken from the countermovement jump test. For the L.E.S.S., two raters watched each jump for all subjects at pre and post-intervention and scored each video based on the criteria determined through prior research (18,20). The scores from jump one and jump two were averaged for each subject at pre and post-intervention. Reliability analysis was performed between rater one and rater two. The values from this analysis ranged from substantial agreement (.61-.8) to almost perfect agreement (.81-1). Because of the high levels of agreement, only scores from one rater were used in statistical analysis. Peak vertical group reaction forces were taken from the initial landing during the CMJ. The force plate used in data collection had a sampling frequency of 1000 Hz. From the force plate data output, only values in the linear Z direction were used. A graph was created for each jump to determine which values occurred during the initial landing from the box drop. Based on this graph, the maximum force output from the initial landing was recorded. The average peak ground reaction force for each participant's two trials was used for the final data analysis.

Change of direction kinematics were recorded by using the Coaches' Eye application. Videos for left and right foot COD at pre and post-intervention for each subject were uploaded to the Coach's Eye, and knee valgus angle and knee flexion angle were determined using the angle tool. To measure knee valgus, a line was drawn from the center of the hip (femoral head) to the center of the knee. This line was then projected down to the level of the ankle. The angle between the ankle and this projection was recorded as the knee valgus angle (13). This measurement was taken from videos recorded in the frontal plane. For knee flexion angle, a line was drawn from the approximate location of the greater trochanter to the lateral epicondyle. A second line was drawn from the lateral epicondyle to the lateral malleolus. The angle between these two lines was recorded as the knee flexion angle. This measure was taken from videos recorded in the sagittal plane.

Statistical Analysis

A 2x2 (group x time) ANOVA test was performed to determine differences between each variable of interest. If interaction effects were present, post-hoc, paired sample, T-tests with

Bonferroni corrections were utilized to determine the specific differences. The alpha value was set a priori at ≤ .05.

Chapter 4: Results

Jump Variables

Peak force during the CMJ landing was reduced from pre to post in both the experimental and control groups, however, this change was not statistically significant, and there was no significant difference between the treatment and control groups. Therefore, there was no main effect for either time or intervention for the CMJ. Additionally, there was no interaction between treatment and time. For L.E.S.S. scores taken from the CMJ, there was no main effect for treatment and no interaction effect between treatment and time. A main effect for time was found ($p = .017$). For both groups, L.E.S.S. scores were better at post-intervention compared to those at pre-intervention.

Sprint and Change of Direction Variables

For 10-yard sprint times taken from the 5-0-5 change of direction test, the was no main effect for treatment and no interaction effect between treatment and time. There was a main effect found for time ($p < .001$) which resulted in a decrease in sprint speed. For the total 5-0-5 time on both the left and right leg, there was no main effect for treatment and no interaction effect for treatment and time. On both legs, there was a main effect for time ($p = .003$) which resulted in slower 5-0-5 times. Right and left leg CODD resulted in no main effect for treatment and no interaction effect for treatment and time. A main effect for time ($p < .001$) was found for both legs. COD ability improved over time, with athletes performing the COD task in less time at post-intervention than at pre-intervention testing.

Joint Kinematics Variables

Knee flexion during the COD task increased in both groups for the right and left legs. Right knee flexion improved by about 3 degrees in both groups and left knee flexion improved by about 1.5 degrees in the treatment group and 9.33 degrees in the control group ($p > .05$). There were no differences for treatment, group, or interaction between treatment and group for either the right or left leg during the COD task. In the treatment group, the right knee valgus angle decreased by about 3.2 degrees from pre to post, however, p was greater than .05. Conversely, the right knee valgus angle increased in the control group by about .67 degrees from pre to post ($p > .05$). Additionally, there were no statistically significant differences found for treatment, group, or interaction between treatment and group. Left knee valgus decreased in both the control and treatment groups pre to post. There was a decrease of about 5.5 degrees in the treatment group ($p = .034$), and there was a decrease of about 1.167 degrees in the control group ($p > .05$).

Chapter 5: Discussion

Jump Variables

The results showed that peak landing forces decreased in both the treatment and control groups. This change in peak ground reaction forces during a vertical jump was likely due to the improved knee flexion in athletes during their landings. While it was expected that landing mechanics, including increased knee flexion, would have changed over time in the treatment group, it was not expected for these improvements to be seen in the control group as well. Although the abbreviated warm-up performed by the control group was not specifically made for injury prevention and did not include any form of feedback, it did include some movements that were similar to those done in the FIFA 11+ warm-up. It is possible that this abbreviated warm-up was able to stimulate improvement in knee flexion. Additionally, it is possible that technique coaching received by both groups during other activities including strength and conditioning sessions influenced the performance of both groups during post-intervention testing.

Along with improved peak ground reaction forces, L.E.S.S. scores improved in both groups from pre to post. Lower scores at postintervention testing were expected for the treatment group as the FIFA 11+ (formerly called F-MARC 11+) has been shown to decrease scores in previous research (23). However, the significant improvement in L.E.S.S scores in the control group was not expected. On average, the preintervention scores for the control group were greater than those of the treatment group. It is possible that because the scores started higher, there was more room to improve landing mechanics in the control group, as compared to the treatment group, which could explain the significant improvement over time. Along with this, the athletes in the control group were all first-year members of the team. (This will be discussed further in the limitations section.) The varying levels of experience between groups could be an explanation for the changes in L.E.S.S. scores. The intervention group was composed, primarily, of sophomores and seniors. The seniors in this group had been exposed to some injury prevention warm-ups and training programs in the past. For example, two seasons prior, these athletes used a modified FIFA 11+ program. Although they did not use the same warm-up utilized in our protocol, it is possible that the previous participation in a variation of this program limited the effect of our intervention.

Sprint and Change of Direction Variables

It was hypothesized that improvements in sprint and COD times would be seen in the treatment group at post-intervention testing. The results showed the opposite effect. Both linear sprint times and COD times were slower at postintervention testing than at preintervention testing. Because the results were similar between groups, it is unlikely that the intervention was a cause of the slower times. Instead, the decline in performance seen in both groups was most likely the result of other confounding variables. Preintervention testing was conducted during the preseason, after an off day. Conversely, due to schedule conflicts, postintervention testing occurred the day after a game. It is possible that athletes who played significant minutes were fatigued from activities prior to testing. Research has shown that fatigue can negatively affect performance when an event occurs less than 24 hours after a game (22). This was the case in our research as the game was played at 7 PM the night before mid-day testing. Additionally, it is likely that all athletes were not well-rested, regardless of playing time, due to traveling late the night before testing. All these factors could have resulted in the slower times seen in post-testing (3).

It is also possible that the in-season training programs were not sufficient to maintain performance levels over the course of a three-month season. During the season, the team had two strength and conditioning sessions scheduled per week. However, sessions were frequently canceled, changed to stretching and active recovery sessions, or limited to band and dumbbell circuit training. For some athletes, this reduced resistance training load and intensity may not have been enough stimulus to improve or retain performance outcomes seen at preintervention testing. During the season, some of these athletes did not do more than stretching, and previous research has shown that the inclusion of resistance training improves performance outcomes as opposed to avoiding it (11). It is also unlikely that the FIFA 11+ would have been enough stimulus to reverse any negative effects of the team's resistance training program.

Finally, as will be discussed in the limitations section, the timing setup for post-intervention testing was different than that of preintervention testing. Although the recommended correction factor for the different timing gate setups was applied to the data prior to running the analysis, it is possible that this change in timing setup influenced COD and linear sprint times.

Joint Kinematics Variables

When compared to the preintervention testing measures, both the intervention and control groups showed greater degrees of knee flexion. An increase in knee flexion would decrease the injury risk for an athlete, which aligns with the goals of the injury prevention program (23). However, because this improvement was seen in both groups, it is not clear that the FIFA 11+ program was the cause of this improvement. Similar to the improvements in L.E.S.S. scores, it is possible that the general S&C coaching that athletes receive throughout the season is enough to cause changes in movement mechanics. Additionally, because mean data was used, it is probable that some athletes had very large improvements in knee flexion while others had only small changes, causing the average to be a less accurate representation of the group. Specifically, for the R knee flexion angle, the degree of change ranged widely within the control group. The results ranged from a decrease in knee flexion by 15 degrees to an increase by 13 degrees, and the median of this data set was an increase by 1.5 degrees. Because the degree of change was vastly different between individual participants, the results may have been different if a measure other than the mean was used.

In addition to knee flexion, there was also an improvement in knee valgus angle in both groups between pre and post-intervention testing. While both groups had decreased knee valgus, the change was only statistically significant in the intervention group. This indicates that the FIFA 11+ intervention was effective in reducing injury risk during COD tasks, which is supported by results found in previous research (23). In contrast, the minimal effect seen in the control group suggests that the abbreviated warm-up utilized by this group was not effective at improving the knee valgus during cutting. It is possible that, with the inclusion of the correct exercises, an abbreviated injury prevention warm-up might be effective at decreasing the amount of knee valgus present during a COD.

Limitations

There were several limitations that also may be responsible for some of the trends in the results. When gathering participants, we used a convenience sample, which required at least half the participants to arrive early to practice. Practices were scheduled from 11 AM to 1 PM when many athletes had classes, so there were a limited number of participants who could arrive at practice early enough to participate in our intervention. These factors, along with three athletes being unable to finish testing, resulted in a small sample size. Many of the variables changed from pre to post-intervention, however, were not statistically significant. It is possible that with a greater sample size, the statistical power would be greater and we could definitively relate these changes over time to the intervention used. Additionally, because of academic schedules, all first-year athletes were unable to arrive early to practice and had to be put in the control group. Conversely, the intervention group was made up of older athletes, some of which have had exposure to various injury prevention programs. The prior exposure may have limited the effect of the intervention regardless if the participant had never done the full FIFA 11+ protocol. It would also be reasonable to expect that an athlete with no prior experience in a training program would demonstrate greater improvements, even to a lesser stimulus, than someone who has been training for longer. Research has shown that large performance improvements early in a training program are due to the formation of new neural connections from a new training stimulus (6).

The differing timing setups between pre and post-intervention CODD testing was also a limitation in this study. During preintervention testing, the setup using the Smart Start had several issues during starting. The system often could not detect the athlete's foot or would activate the timing before the athlete was prepared to run. This caused athletes to perform several trials and took a significant amount of time. As a result, the timing system for postintervention testing was switched to a Photogate start. While we corrected for this difference based on the instructions provided in the Brower Timing System manual, there were still differences in sprint times that might have been due to the change in setup. However, if this correction factor accurately accounted for the change in setup, fatigue, due to testing the day after a game, could be a limitation in this test.

Finally, two different tasks were used to collect data. Kinetic data was collected from a vertical jump task while kinematic data was collected from a COD task. While these tasks, and the variables collected, are related it is possible that the tasks involved varying execution strategies that could make it difficult to compare variables across tasks.

Conclusion

Overall, while most variables showed change over time, there was not enough statistical power to determine that the FIFA 11+ protocol resulted in less injury risk than an abbreviated warm-up. The intervention group did demonstrate improvements related to injury risk variables, however, the control group also showed similar improvements. Additionally, the intervention group did not demonstrate any significant changes in performance compared to the control, so it cannot be said that the FIFA 11+ had any effect on the performance of a COD task. In contrast, the intervention group did significantly improve knee valgus during a COD, which indicates that the FIFA 11+ program is effective in improving this variable of injury risk.

The results showed that both groups saw improvement in some variables of injury risk. This may suggest that even an abbreviated injury prevention warm-up can be an effective means of reducing ACL injury risk in athletes. Further research may be needed to determine which exercises of an IPP will provide athletes with the greatest reduction of their injury risk. Our results also suggest that IPPs can be successfully implemented without the feedback of a trained coach or practitioner, which may make application into practice settings easier for teams without these resources available.

Finally, the results may open discussions on the necessity of a proper strength and conditioning program even during in-season sports training. An IPP may not be enough stimulus on its own to improve either injury risk or sports performance outcomes. It is reasonable to assume that proper frequency and intensity of strength training are required to maintain and improve performance outcomes. While this study did not directly look at this variable, future research may be needed to explore the best practice for concurrent IPP programs and strength training programs.

Figures

Figure 1: Drop Vertical Jump Landing Test (20)

Figure 2: Drop Vertical Jump Landing Equipment Set-Up (20)

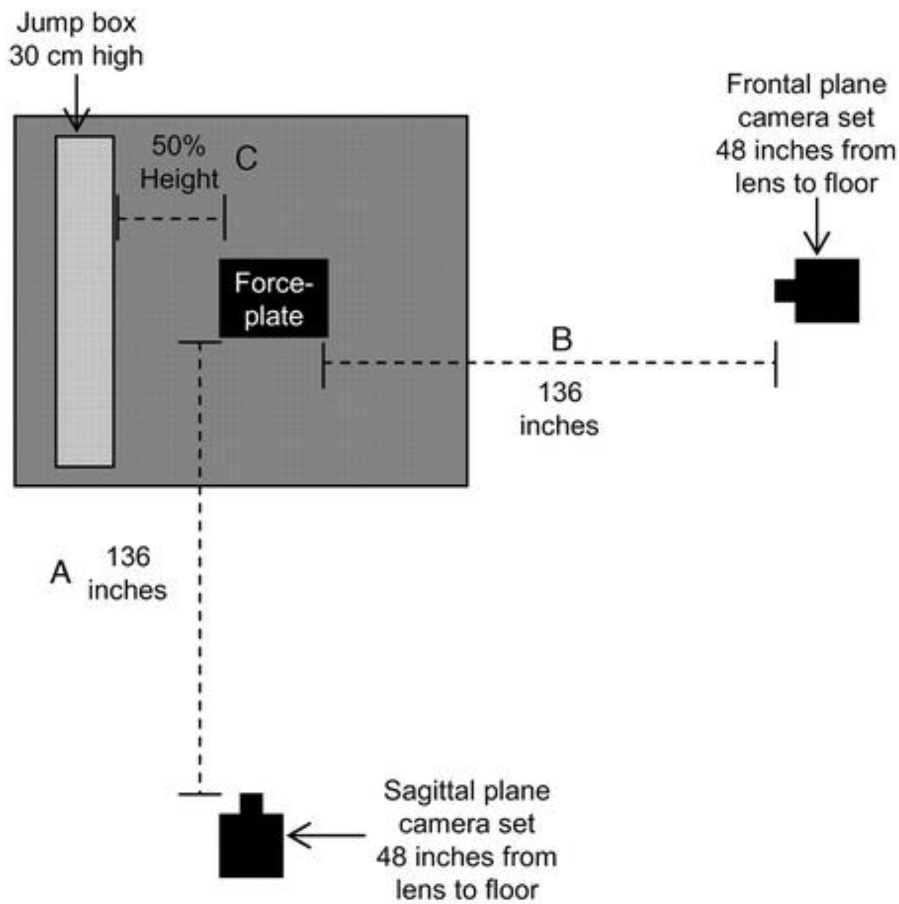
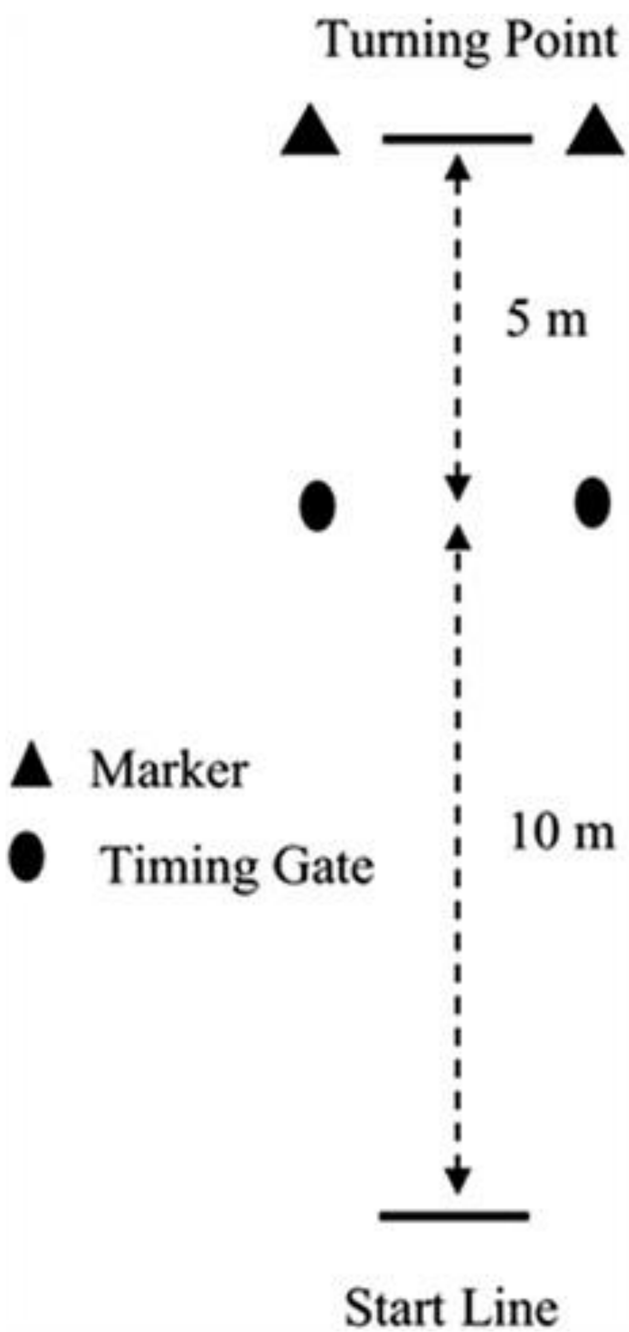


Figure 3: Landing Error Scoring System (18)

Landing Error Scoring System Item	Operational Definition of Error	Scoring
Knee flexion: initial contact	The knee is flexed less than 30° at initial contact.	0 = Absent 1 = Present
Hip flexion: initial contact	The thigh is in line with the trunk at initial contact.	0 = Absent 1 = Present
Trunk flexion: initial contact	The trunk is vertical or extended on the hips at initial contact.	0 = Absent 1 = Present
Ankle plantar flexion: initial contact	The foot lands heel to toe or with a flat foot at initial contact.	0 = Absent 1 = Present
Medial knee position: initial contact	The center of the patella is medial to the midfoot at initial contact.	0 = Absent 1 = Present
Lateral trunk flexion: initial contact	The midline of the trunk is flexed to the left or the right side of the body at initial contact.	0 = Absent 1 = Present
Stance width: wide	The feet are positioned greater than shoulder width apart (acromion processes) at initial contact.	0 = Absent 1 = Present
Stance width: narrow	The feet are positioned less than shoulder width apart (acromion processes) at initial contact.	0 = Absent 1 = Present
Foot position: external rotation	The foot is externally rotated more than 30° between initial contact and maximum knee flexion.	0 = Absent 1 = Present
Foot position: internal rotation	The foot is internally rotated more than 30° between initial contact and maximum knee flexion.	0 = Absent 1 = Present
Symmetric initial foot contact: initial contact	One foot lands before the other foot or 1 foot lands heel to toe and the other foot lands toe to heel.	0 = Absent 1 = Present
Knee-flexion displacement	The knee flexes less than 45° between initial contact and maximum knee flexion.	0 = Absent 1 = Present
Hip-flexion displacement	The thigh does not flex more on the trunk between initial contact and maximum knee flexion.	0 = Absent 1 = Present
Trunk-flexion displacement	The trunk does not flex more between initial contact and maximum knee flexion.	0 = Absent 1 = Present
Medial-knee displacement	At the point of maximum medial knee position, the center of the patella is medial to the midfoot.	0 = Absent 1 = Present
Joint displacement	Soft: the participant demonstrates a large amount of trunk, hip, and knee displacement.	0 = Soft
	Average: the participant has some, but not a large amount of, trunk, hip, and knee displacement.	1 = Average
	Stiff: the participant goes through very little, if any, trunk, hip, and knee displacement.	2 = Stiff
Overall impression	Excellent: the participant displays a soft landing with no frontal-plane or transverse-plane motion.	0 = Excellent
	Average: all other landings.	1 = Average
	Poor: the participant displays large frontal-plane or transverse-plane motion, or the participant displays a stiff landing with some frontal-plane or transverse-plane motion.	2 = Poor

Figure 4: 505 Change of Direction Test Set-Up (17)



References

1. Celebrini, RG, Eng, JJ, Miller, WC, Ekegren, CL, Johnston, JD, Depew, TA, et al. The effect of a novel movement strategy in decreasing ACL risk factors in female adolescent soccer players: A randomized controlled trial. *Clin J Sport Med Off J Can Acad Sport Med* 24: 134–141, 2014.

2. Celebrini, RG, Eng, JJ, Miller, WC, Ekegren, CL, Johnston, JD, and MacIntyre, DL. The effect of a novel movement strategy in decreasing ACL risk factors in female adolescent soccer players. *J Strength Cond Res* 26: 3406–3417, 2012.

3. Charest, J and Grandner, MA. Sleep and Athletic Performance: Impacts on Physical Performance, Mental Performance, Injury Risk and Recovery, and Mental Health. *Sleep Med Clin* 15: 41–57, 2020.

4. Condello, G, Kernozek, TW, Tessitore, A, and Foster, C. Biomechanical analysis of a change-of-direction task in college soccer players. *Int J Sports Physiol Perform* 11: 96–101, 2016.

5. Dai, B, Garrett, WE, Gross, MT, Padua, DA, Queen, RM, and Yu, B. The effect of performance demands on lower extremity biomechanics during landing and cutting tasks. *J Sport Health Sci* 8: 228–234, 2019.

6. Haff, GG and Triplett, NT (eds.). Essentials of Strength and Conditioning. Fourth. Human Kinetics, Inc., 2016.

7. Havens, KL and Sigward, SM. Cutting mechanics: Relation to performance and anterior cruciate ligament injury risk. *Med Sci Sports Exerc* 47: 818–824, 2015.

8. Herzog, MM, Marshall, SW, Lund, JL, Pate, V, and Spang, JT. Cost of Outpatient Arthroscopic Anterior Cruciate Ligament Reconstruction Among Commercially Insured Patients in the United States, 2005-2013. *Orthop J Sports Med* 5, 2017.Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5302102/

9. Hewett, TE, Ford, KR, Hoogenboom, BJ, and Myer, GD. Understanding and preventing ACL injuries: Current Biomechanical and epidemiologic considerations - Update 2010. *North Am J Sports Phys Ther NAJSPT* 5: 234–251, 2010.

10. Hootman, JM, Dick, R, and Agel, J. Epidemiology of Collegiate Injuries for 15 Sports: Summary and Recommendations for Injury Prevention Initiatives. *J Athl Train Natl Athl Train Assoc* 42: 311–319, 2007.

11. de Hoyo, M, Pozzo, M, Sañudo, B, Carrasco, L, Gonzalo-Skok, O, Domínguez-Cobo, S, et al. Effects of a 10-week in-season eccentric-overload training program on muscle-injury prevention and performance in junior elite soccer players. *Int J Sports Physiol Perform* 10: 46–52, 2015.

12. Jones, PA, Herrington, LC, and Graham-Smith, P. Technique determinants of knee joint loads during cutting in female soccer players. *Hum Mov Sci* 42: 203–211, 2015.

13. Krackow, KA. The Measurement and Analysis Of Axial Deformity at the Knee. *Homer Stryker Cent* 58, 2008.

14. Lindblom, H, Waldén, M, and Hägglund, M. No effect on performance tests from a neuromuscular warm-up programme in youth female football: a randomised controlled trial. *Knee Surg Sports Traumatol Arthrosc* 20: 2116–2123, 2012.

15. Marshall, BM, Franklyn-Miller, AD, King, EA, Moran, KA, Strike, SC, and Falvey, ÉC. Biomechanical factors associated with time to complete a change of direction cutting maneuver. *J Strength Cond Res* 28: 2845–2851, 2014.

16. Morrison, K, Albert, WJ, and Kuruganti, U. Biomechanical assessment of change of direction performance in male university soccer players. 4, 2015.

17. Nimphius, S, Callaghan, SJ, Spiteri, T, and Lockie, RG. Change of Direction Deficit: A More Isolated Measure of Change of Direction Performance Than Total 505 Time. *J Strength Cond Res* 30: 3024–3032, 2016.

18. Padua, DA, DiStefano, LJ, Beutler, AI, de la Motte, SJ, DiStefano, MJ, and Marshall, SW. The Landing Error Scoring System as a Screening Tool for an Anterior Cruciate Ligament Injury-Prevention Program in Elite-Youth Soccer Athletes. *J Athl Train Allen Press* 50: 589–595, 2015.

19. Padua, DA, DiStefano, LJ, Hewett, TE, Garrett, WE, Marshall, SW, Golden, GM, et al. National Athletic Trainers' Association Position Statement: Prevention of Anterior Cruciate Ligament Injury. *J Athl Train* 53: 5–19, 2018.

20. Padua, DA, Marshall, SW, Boling, MC, Thigpen, CA, Garrett, WE, and Beutler, AI. The Landing Error Scoring System (LESS) Is a Valid and Reliable Clinical Assessment Tool of Jump-Landing Biomechanics: The JUMP-ACL Study. *Am J Sports Med* 37: 1996–2002, 2009.

21. Pappas, E, Shiyko, MP, Ford, KR, Myer, GD, and Hewett, TE. Biomechanical deficit profiles associated with ACL injury risk in female athletes. *Med Sci Sports Exerc* 48: 107–113, 2016.

22. Sanchez-Sanchez, J, Sanchez, M, Hernandez, D, Ramirez-Campillo, R, Martínez, C, and Nakamura, FY. Fatigue in U12 Soccer-7 Players During Repeated 1-Day Tournament Games-A Pilot Study. *J Strength Cond Res* 33: 3092–3097, 2019.

23. Thompson, JA, Tran, AA, Gatewood, CT, Shultz, R, Silder, A, Delp, SL, et al. Biomechanical effects of an injury prevention program in preadolescent female soccer athletes. *Am J Sports Med* 45: 294–301, 2017.

24. Vanrenterghem, J, Venables, E, Pataky, T, and Robinson, MA. The effect of running speed on knee mechanical loading in females during side cutting. *J Biomech* 45: 2444–2449, 2012.

25. Vescovi, JD and VanHeest, JL. Effects of an anterior cruciate ligament injury prevention program on performance in adolescent female soccer players. *Scand J Med Sci Sports* 20: 394–402, 2010.

26. Zarei, M, Abbasi, H, Daneshjoo, A, Barghi, TS, Rommers, N, Faude, O, et al. Long-term effects of the 11+ warm-up injury prevention programme on physical performance in adolescent male football players: a cluster-randomised controlled trial. *J Sports Sci* 36: 2447–2454, 2018.

27. The female ACL: Why is it more prone to injury? *J Orthop* 13: A1–A4, 2016.

28. TCi+instructions+2017R4.pdf. Available from: https://static1.squarespace.com/static/5be35e537c932755af965d6b/t/5c3e015cc2241b7f36d93221/1547567456814/TCi+instructions+2017R4.pdf

Appendix A

FIFA 11+ Injury Prevention Warm-Up Program

FIFA 11+

PART 1 RUNNING EXERCISES · 8 MINUTES

1 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**

2 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.**

3 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.**

4 RUNNING CIRCLING 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.**

5 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**

6 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.**

PART 2 STRENGTH · PLYOMETRICS · BALANCE · 10 MINUTES

LEVEL 1 | LEVEL 2 | LEVEL 3

7 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 20-30 sec. Your body should be in a straight line. Try not to sway or arch your back. **3 sets.**

7 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.**

7 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.**

8 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.**

8 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.**

8 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.**

9 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.**

9 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.**

9 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.**

10 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.**

10 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.**

10 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.**

11 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.**

11 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.**

11 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.**

12 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.**

12 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 m sideways 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.**

12 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.**

PART 3 RUNNING EXERCISES · 2 MINUTES

13 RUNNING ACROSS THE PITCH

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

14 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 cross 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.**

15 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.**

MY GAME IS FAIR PLAY FIFA

F-MARC FOOTBALL FOR HEALTH FIFA