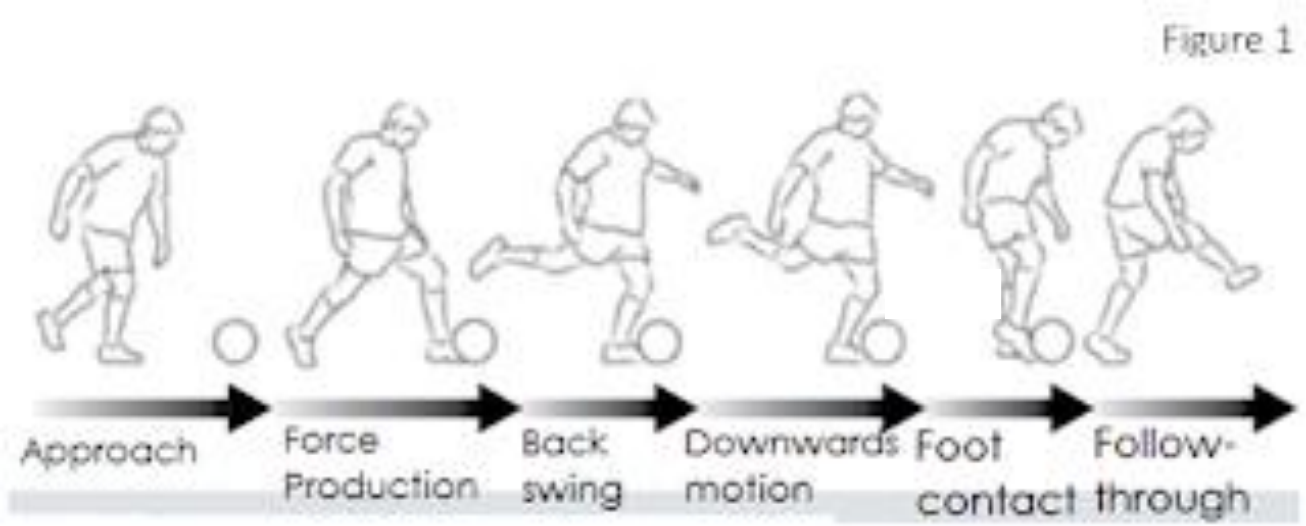
# Kinematic Analysis of Football instep kick for the dominant foot to affect ball velocity

## Part A: Protocol

**MELANIE WRIGHT**




**EXSC321 Biomechanics QLD**

# PURPOSE

The In-step kick in Football is one of the main four Key Performance Indicators in the Skill Acquisition developmental stage known as Striking the ball.

The Biomechanical analysis protocol will evaluate sagittal plane kinematics and focus on the pre swing mechanisms plus the impact of the foot-ball collision which effects ball velocity (J.Sinclair et al., 2014).

These biomechanical variables are an observed determinant between novice vs skilled players and when performed with a high degree of skill ensure accurate passing and goal scoring opportunities. This enables the athlete to generate sufficient force in the execution phase which determines maximum ball velocity. These variables can Indirectly influence the outcome of a match

# PURPOSE

This biomechanical analysis protocol focuses on the relevance of the kinematic variables for in-step football kicking which directly contribute to the accuracy and velocity of the projectile.

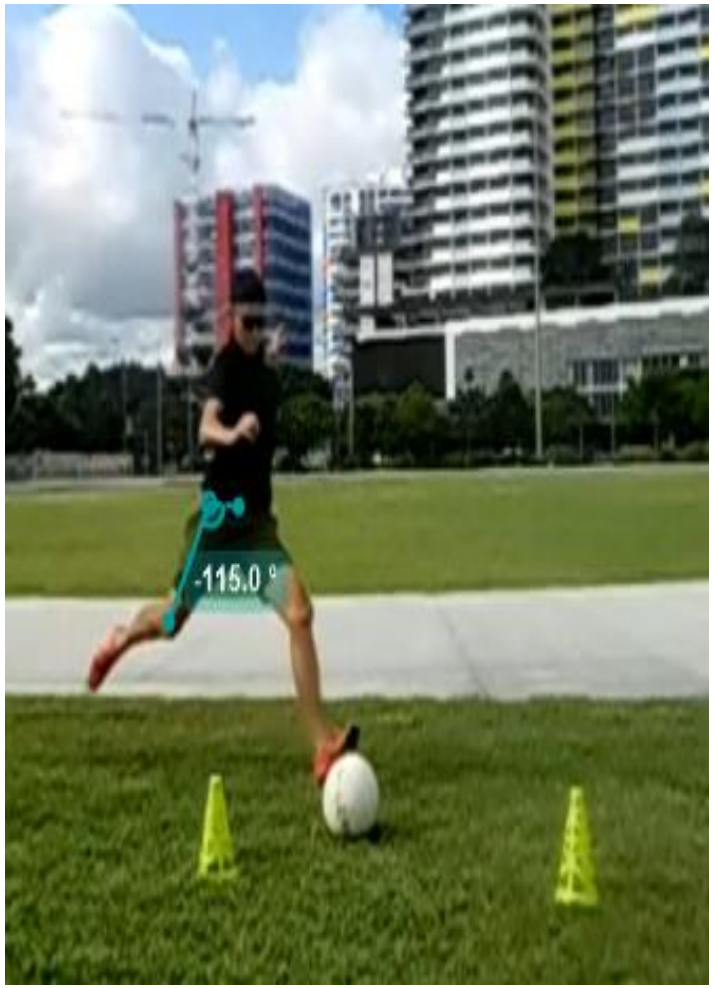
The protocol is designed to assess novice vs skilled performers when completing the task of the in-step football kick.
There has been observed correlations in previous literature that shows a relationship in biomechanical kinematics between AFL drop punt kicking and football kicking within the realm of the foot-ball collision at impact (Ball, 2008).

## Protocol Background

# Kicking leg Hip Extension (pre-swing phase)

During the last step of the movement, in the kicking leg swing phase of knee flexion the angle is approximately 80% greater than that of a novice performer (Gongbing & Westerhoff, 2007). Literature studies conclude that skilled performers have an increased range of motion in the hips, this enables an efficient movement pattern and leads to increased ball  contact velocity (Gongbing & Westerhoff, 2007).

When performing the in-step kick skilled athletes have greater hip extension on the pre-kick phase of the movement (Gongbing & Westerhoff, 2007).




| Novice vs skilled | | |
|---|---|---|
| | **MEAN** | **SD** |
| Novice athlete | 72˚ | 7 |
| Skilled athlete | 130 | 10 |

**Table 1:** Normative data for in-step kick pre-swing phase hip extension. Skilled vs novice athlete
**(**Gongbing & Westerhoff, 2007)

## Key Variable (i)

# Kicking leg Knee Flexion (pre-swing phase)

Knee flexion in the pre –swing phase is an impactful determinant between novice and advanced individuals when assessing foot/ball velocity (Sakamoto et.al., 2016).

Research suggests that increased knee flexion when moving through the swing phase to the execution phase into knee extension provides a greater foot velocity when colliding with the ball (Sakamoto et.al., 2016).

In the above example we see the amount of knee flexion produced provides the acting force (mass*acceleration) on the object and the swing phase provides the momentum (mass*velocity)

Skilled performers when effecting the in-step kick have 108˚ + 8˚ of knee flexion compared with novice performers which have 80˚ + 10˚ (Gongbing & Westerhoff, 2007).

# Kicking foot - velocity at ball impact (execution phase)

There are numerous factors that affect ball velocity at impact, such as centre of gravity of the foot, place of impact on the ball, the rigidity of the foot at ball impact, the effect of musculature which produces force and what is thought to have the greatest impact is that of foot velocity [Sakamoto et al., 2016].

Proximal to distal energy transfer is generated from the lower extremities and thus this is thought to produce a strong correlation between foot to ball velocity and ball velocity after impact [Sakamoto et al., 2016].

In a study of 6 female football players the in-step kick was performed and highlighted the relevance of hip, knee and ankle joint mechanisms as key variables in foot to ball velocity.

| Normative Data | Mean | SD |
|---|---|---|
| Barfield et al., 2002 | 16.2 | 2.3 |
| Sakamoto et al., 2016 | 17.8 | 1.4 |

**Table 2:** Average foot velocity of the in-step kick for female players [sakamoto et al., 2016; Barfield et al., 2002]

# How to Ensure an accurate in-step football kick?

- Choose the best piece of grass to place the ball (if the ball is placed in a divot, accuracy & trajectory is compromised)
- Ensure run up is consistent (approx. 3 steps, angle not excessive )
- Non dominant foot is placed square to the ball on landing prior to dominant foot ball contact
- Shoulder (non dominant side) is used as leverage in the last step to effectively square the hips (hip rotation effects the direction the ball will travel)
- Pre swing phase in the final step is where power is generated through the lower leg swing
- Drive through the ball with the medial 2/3 of the distal section of the foot
- Head remains pointed down at point of ball contact
- To gain upward momentum in a football place kick there is a slight lean backwards in the upper torso to lift the projectile into the air (like a golf swing)
- Execution phase involves using above methods to generate applicated force (mass x acceleration) to strike the object
- The follow through should be significant in the dominant foot to provide the necessary momentum, this ensures the foot drives through the ball (mass x velocity)

# Client requirements for protocol

- Is there any reasons that might affect the data collection session?
- Pre-participant exercise screen form (ESSA)
- Equipment: Football boots, ball, grass surface, goal posts
- Kinematic markers placed on the participant in Anatomical position for sagittal assessment (refer Figure 1 for locations)
- Warmup : FIFA 11 followed by static stretches (10mins)
- Participant advised of order of events
    - (i) How the testing and in what order the testing will be conducted
    - (ii) Read through the Coaching cues for how to execute the skill
    - (iii) A demonstration of the expectation for successful data collection
    - (iv) Cues for when to commence the trials

- Approx duration of trial: 1hour
- Target number of trials: 10
- Successful trial – where there is no miskick and dominant kicking foot strikes the ball withing the
- 1m x 1m marked area (any unsuccessful trials will be retaken)

# Marker & Sensor Placements

## Kinematic Markers

Spherical or electrical tape in a cross shape placed in locations specified on the sagittal plane (Figure 1)

- RSAP: Right Superior Acromion Process (RSAP);
- RLGT: Right Lateral Greater Trochanter (RLGT);
- RFE: Right Femoral Epicondyle (RFE);
- RLM: Right Lateral Malleoli (RLM);
- RFM: Right Fifth Metatarsal (RFM);


**Figure 1:** Kinematic markers placed in the sagittal plane of the dominant kicking leg using Tacker application.

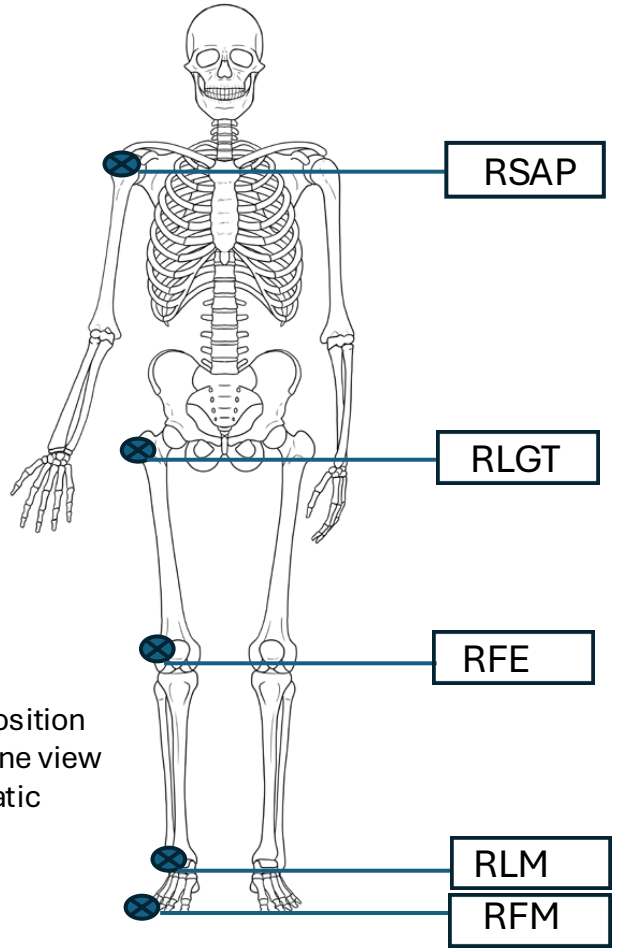



**Figure 2** : Anatomical position marking the Sagittal plane view of positioning of Kinematic markers

## Methods: Data Collection

# Equipment/Lab setup

- Field based testing (football pitch)
- Grass surface
- Measuring tape
- Spherical or electrical tape
- Ensure all markers on the participant are visible
- 1* 2D Nikon video camera, sample 250Hz+ set up to record data in the sagittal plane of the participant
- 1* Tripod
- 2* cones
- Kinovea & Tracker Application for Data Analysis

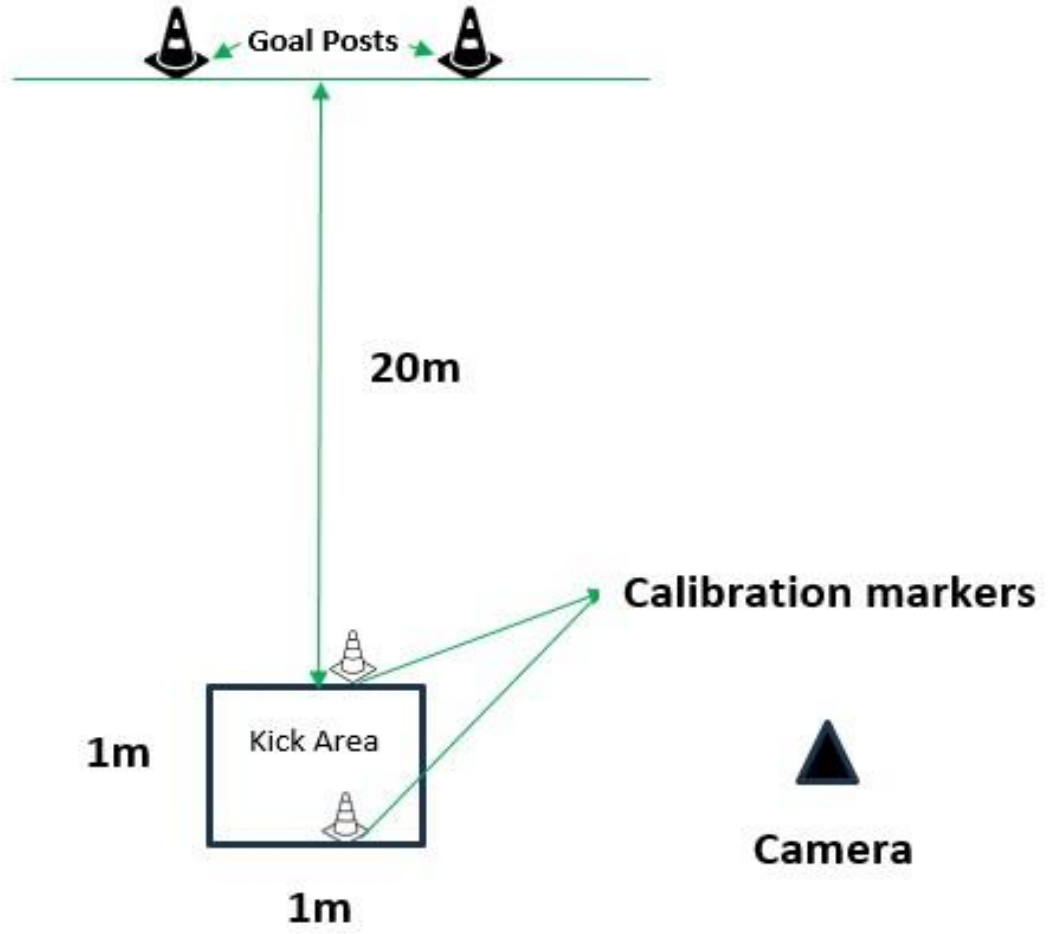



**Figure 3**: Data collection equipment setup, including goals, markers, camera + tripod setup in sagittal view and calibration area.

## Methods: Data Collection

# Data Analysis

Kicking leg Hip Extension

- Calculated in Kinovea
- Defined in table 4;

Kicking leg knee flexion

- Calculated in Kinovea
- Defined in table 4;

Kicking Foot velocity @ ball impact

- Calculated in Kinovea and Tracker
- Defined in table 4;

# Variable Definitions

**Table 3:** Definitions of variables of interest

| Variable Name | Hip Extension (pre phase) | Knee Flexion (pre phase) | Foot-Ball Velocity (Execution phase) |
|---|---|---|---|
| **Units** | Degrees (deg.) | Degrees (deg.) | Metres per second ($m.s^{-1}$) |
| **Filtering** | If available, 4th order low-pass Butterworth filter (8Hz) | If available, 4th order low-pass Butterworth filter (8Hz) | If available, 4th order low-pass Butterworth filter (8Hz) |
| **Variable definition** | Angle from torso, through pelvis (axis of rotation) to thigh on the dominant side of the body | Angle at the last step, knee at flexion from pre-swing phase from pelvis to knee (axis of rotation) to ankle | Time variation between last step kicking leg pre swing knee flexion to foot-ball swing phase to ball collision |
| **Time point definition** | Peak value at hip in extension in dominant leg at pre swing phase adjacent to femur & torso | Peak value at knee flexion in dominant leg at pre swing phase adjacent to femur & tibia | Peak value between kicking leg knee flexion and foot-ball collision in the execution phase |

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# Part B: Client Report

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**EXSC321 BIOMECHANICS QLD**

# Client Details

**Name:** Melanie Wright
**Age:** 44years
**Height:** 175cm
**Weight:** 60kg
**Sport:** Football
**Level:** Intermediate - Advanced
**Weekly Training Regime:** 3 training sessions per week
**Injuries:** Nil
**Date:** 10/03/2024
**Assessment Focus:** Coach identified inconsistency in kicking velocity

## Client Background

Melanie's kick was assessed using the Football In-step kick protocol (version 1.0)
All aspects of testing are as per protocol.

**Data collection point**: Perry Park football training ground. Brisbane, Australia.

**Leg Analyzed**: Right

**Camera**: Nikon S7000

**Footwear:** Nike Phantom Ninja Football Boots

**Other Equipment**: Size 5 Summit Launch Footballs

## Test Information

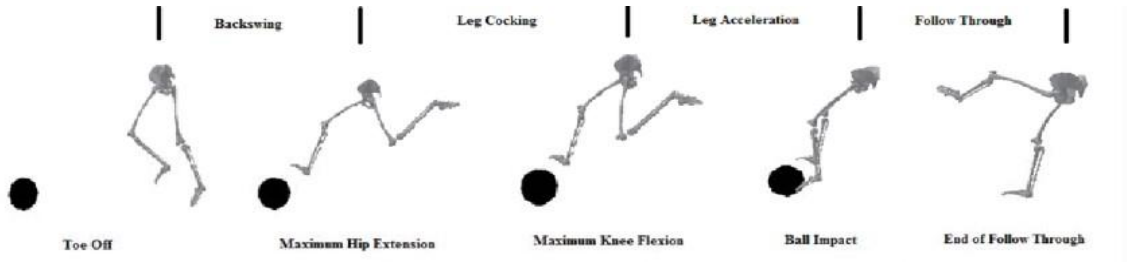
# Kicking leg hip extension (pre-swing phase)

- Hip extension in the pre swing phase is of a standard level when compared with a skilled performer.
- Technique would indicate a consistent approach for the pre-swing phase with relation to hip extension when analyzing the in-step kick when compared to skilled performers.
- Further study could incorporate the analysis of other variables that may attribute to hip extension variations, such as; run up to the ball, angle of run up, support foot placement and ball displacement.
- This analyses would indicate that there is no major technique required to gain further hip extension, with some minor tweaks it might be beneficial to increase hip Range of Motion (ROM) to enhance performance.

**Table 4:** Hip extension in the sagittal plane, dominant kicking leg. Data presented is relative to standard normative data in comparison with skilled performers [Gongbing & Westerhoff, 2007].

| | Mean (deg) | SD |
|---|---|---|
| Skilled performer | 130 | 10 |
| You | 113.62 | 1.6 |

**Figure 4** In-step kick phases [A. Navandar et al., 2016]




## Findings and Recommendations

# Kicking leg knee flexion (pre-swing phase)

- Knee flexion in the dominant kicking leg is of an acceptable range when comparing with skilled performers.
- Analyses indicate that knee flexion is consistent across the trials.
- Other variables could be considered for future testing that may influence knee flexion, such as; the stride length of the final step in the pre swing phase, the purpose of the in-step kick with relation to how to position the torso at ball contact.

**Table 5** Knee flexion in the sagittal plane, dominant kicking leg. Data presented is relative to standard normative data in comparison with skilled performers [Gongbing & Westerhoff, 2007].

| | Mean (deg) | SD |
|---|---|---|
| Skilled performer | 108 | 8 |
| You | 99.3 | 1.5 |

- Other aspects of the in-step kick might benefit prior to addressing knee flexion for enhancing skill performance.

**Figure 5:** Knee flexion in the sagittal plane, dominant kicking leg with use of Kinovea to analyze the movement.


## Findings and Recommendations

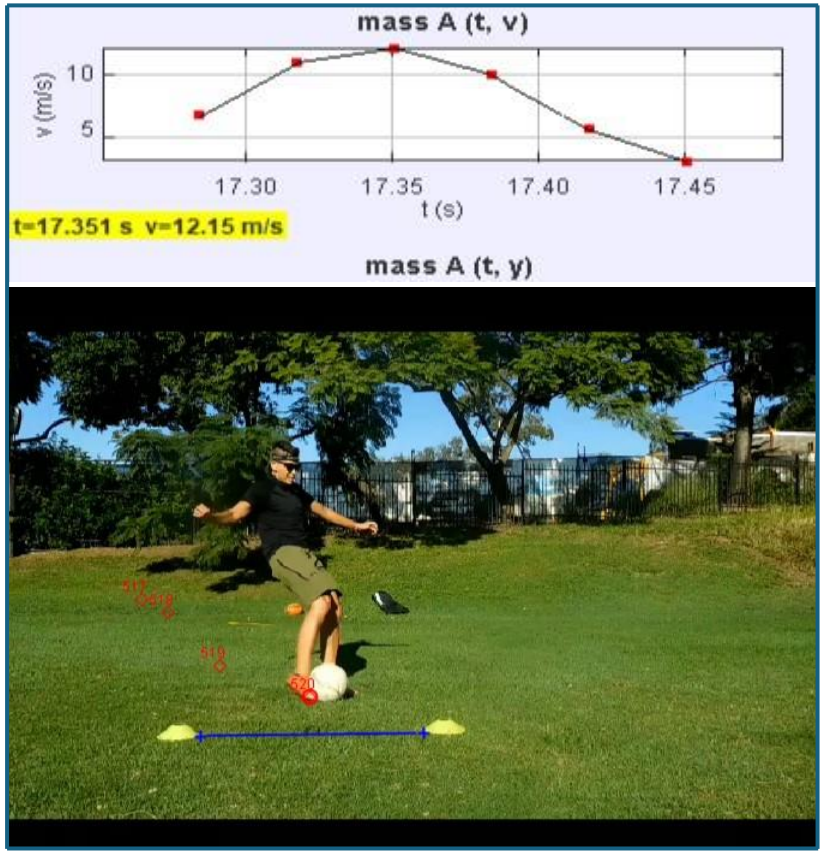
# Kicking foot - velocity @ ball impact (execution phase)

- Foot to ball velocity is below the skilled performers mean average.
- When assessing foot to ball velocity, it can be noted that the follow through in these trials are an area for improvement. To indicate that follow through is a good indicator of momentum to affect force generation in the movement. In this study the generation of foot to ball velocity affects ball displacement.
- Other variables could also impact foot velocity at ball impact
- With the implementation of recommendations (summary section), foot to ball velocity may be improved.

**Table 6:** Foot velocity at ball impact in the sagittal plane, dominant kicking leg. Normative data in comparison with a skilled performer [Gongbing & Westerhoff, 2007]

| | Mean (m/s) | SD |
|---|---|---|
| Skilled performer | 17.8 | 1.4 |
| You | 12.6 | 1.0 |

**Figure 6** Foot velocity at ball impact in the sagittal plane, the dominant kicking leg with use of Tracker application.




## Findings and Recommendations

# Recommendations on how to Improve Performance?

**Adductor muscle activation exercises**

During the swing phase of an in step kick the Adductor longus activates at approx. 40%, therefore implement exercises to strengthen this region e.g. Pilates & resistance bands (https://www.youtube.com/watch?v=IUYW2AwDLFU). This is recommended to increase kicking velocity & reduce injury risk [Charnock et al., 2009]

**Lower limb S&C program**

Implement a lower limb strength program (S&C) which incorporates plyometrics [Chimera et al., 2004] to increase power and build musculature required for increasing average kicking distance as per literature evidence [Rubley et al., 2011]. This will also increase the stretch shortening cycle which is well researched as being a key characteristic in an effective in-step kick [Bober et al., 1987]

**Hip range of motion**

Research suggests that incorporating dynamic hip range of motion (ROM) exercises in the warmup protocol increases hip mobility. In biomechanical terms, with the use of dynamic stretching this provides positive stimuli for angular velocity at the hip and lower extremities [Amiri-Khorasani et al., 2011].

**Repetition**

Repetition in practice with focus on in-step kick variables to promote hip extension, knee flexion, support leg placement and shoulder rotation to rotate hips. With the implementation of a strength program, repetition will likely improve the technique element of the in-step kick. The importance of repetition in sporting movements is highlighted in Advanced Coaching Football Australia (FA) manuals and in the Sport NZ link under the 3 R's (https://balanceisbetter.org.nz/repetition-realism-and-relevance/)

## Summary

# What are the next steps?

- Muscle strength is most likely an effective measure to applying maximum power generation for the in-step football kick [Manolopoulos., 2013].
- Resistance training to incorporate Isometric and plyometric is a proven measure throughout literature studies to enhance kicking performance. Specifically in the generation of maximal foot to ball contact and improved angular velocity of joints at impact [Manolopoulos., 2013].
- The Australian Strength and Conditioning association (ASCA) recommend at an elite level, football players should be able to squat approx. 1.5 times their body weight as a benchmark indicator for strength. This could be a useful intervention when considering the type of prescription and modality associated with improving the in-step kick [ https://www.strengthandconditioning.org/jasc-29-2/2956-editorial-vol-29-iss02 ].
- As such, a 10-week program resistance training program is recommended training 2-3 times per week [Manololpoulos., 2013] with the focus on plyometrics, isometrics and strength/power integration.
- A follow up biomechanical analyses is advised between weeks 10-12 to assess in-step kick progression.

# Summary

**In this report all references are clickable links directly to the DOI of the article.**

# References

# Trial data obtained to analyze variables contributing to In-step football kicking

**Table 7 :** Supplementary data table: Results of biomechanical analysis across 3 variables as KPI's of kicking performance. Individually recorded with mean and standard variables. Embedded as an Excel document for coaching staff future access and reference.

| Trial | Kicking leg Hip Extension (pre-swing)° | Kicking Leg Knee Flexion (pre-swing)° | Kicking foot velocity at ball Impact (m/s) |
|---|---|---|---|
| **1** | 112.8 | 98.6 | 11.92 |
| **2** | 115.2 | 97.7 | 15.64 |
| **3** | 110.9 | 101.2 | 11.82 |
| **4** | 115.9 | 98.7 | 12.15 |
| **5** | 112.8 | 101.8 | 12.45 |
| **6** | 115.5 | 98.2 | 12.6 |
| **7** | 112.1 | 100.1 | 12.05 |
| **8** | 113.6 | 99 | 13.2 |
| **9** | 115.3 | 101.5 | 11.81 |
| **10** | 112.1 | 97.2 | 13.12 |
| **Mean** | 113.62 | 99.4 | 12.676 |
| **SD** | 1.655777763 | 1.560769041 | 1.09711622 |

# Supplementary Data