An Examination of Action Capabilities and Movement Time during a Soccer Anticipation Task

Effets des qualités physiques et du temps de mouvement sur une tâche d'anticipation en football

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Abstract

This study examined the anticipation responses of twenty skilled youth players who were assigned to either a change of direction (CODG) or small-sided games group (SSGG). Action capabilities were assessed via a countermovement vertical jump (CMVJ), 20 m sprint, 5 m acceleration and arrowhead change of direction (COD) test. Anticipation was measured via a soccer-specific anticipation test (SSAT), which required participants to anticipate the actions of an opposing player and intercept a pass. Pre- and post-intervention testing procedures were identical for both groups. Following training there was an overall improvement in CMVJ performance ($p < .05$, $r = .52$) for both training groups and this improvement was correlated with movement initiation in the SSAT ($r = .61$, $p < .05$). The novel findings of this study highlight that different training modes can potentially have a positive impact on anticipation performance. Further investigation focussing on an examination of the relationship between training, anticipation, and action capabilities in sport is warranted for the development of research and applied perspectives in expertise.

Keywords

Agility, anticipation, soccer, plyometric, small-sided games

Résumé

L'objectif de cette étude était d'évaluer les capacités d'anticipation de 20 joueurs de football qui ont suivi un entrainement basé soit sur des changements de direction ou bien sur des jeux réduits. Les qualités physiques ont été mesurées par un saut en contre mouvement, un sprint de 20m et un test de changement de direction. Les capacités d'anticipation ont été mesurées par le « soccer specific anticipation test » (SSAT). Ce test demandait aux participants d'anticiper la direction de la passe d'un adversaire. Les évaluations pré et post entrainement ont été identiques pour les deux groupes. A la suite de la période d'entrainement, une amélioration de la performance en saut en contre mouvement dans les deux groupes ($p < 0,05$; $r = 0,52$) a été observée. Cette amélioration était corrélée avec la performance réalisée lors du SSAT ($r = 0,61$; $p < 0,05$). Les nouveaux résultats de cette étude montrent que différents types d'entrainement peuvent potentiellement avoir des effets positifs sur les capacités d'anticipation. Des recherches supplémentaires examinant la relation entre l'entrainement, l'anticipation et les qualités physiques en sport sont nécessaires.

Mots clés:

Agilité, anticipation, football, pliométrie, jeux réduit

Introduction

Athletes in team-sports perform multiple directional changes, accelerations and decelerations during complex game situations (Paul, Gabbett, & Nassis, 2016; Sheppard & Young, 2006; Young, Dawson, & Henry, 2015). In the strength and conditioning literature, the ability to perform these high-speed actions has commonly been referred to as agility (Gabbett, Kelly, & Sheppard, 2008; Paul et al., 2016; Scanlan, Humphries, Tucker, & Dalbo, 2014; Sheppard & Young, 2006; Young et al., 2015). The use of the term agility as a facet of skill has recently received much debate, primarily because studies have often failed to delineate on the distinction between change of direction (COD) and agility (for a review, see Paul et al., 2016). Increasing consensus emphasises that COD can be best conceived as pre-planned movements, which are controlled or timed independent of the onset of a stimulus, whilst agility encapsulates a rapid whole-body movement that is coordinated relative to a stimulus (Paul & Akenhead, 2018; Young et al., 2015). However, the broad conceptualisation of the environment as a *stimulus* lacks accuracy and potentially invites the use of inappropriate testing and training methodologies. For instance, many approaches to the study of agility have required athletes to respond to light stimuli (Morland, Bottoms, Sinclair, & Bourne, 2013; Sekulic, Krolo, Spasic, Uljevic, & Peric, 2014), which will lead to the examination of processes that are different to those required in sport situations that are predicated on sport-specific information, such as the actions of an opponent (Paul et al., 2016). Thus, based on contemporary views, agility can be considered as a whole-body movement that is coordinated relative to information sampled from a representative performance environment (Paul & Akenhead, 2018; Paul et al., 2016; Young et al., 2015).

The emphasis in agility research on the importance of studying performance in representative task conditions (e.g., Paul et al., 2016; Young et al., 2015) complements an extensive body of anticipation research, which has examined how skilled athletes control their actions through the pick-up of information from an opponent's movements (Dicks, Davids & Button, 2009), and from game situations at large (Abernethy, Gill, Parks & Packer, 2001). However, in contrast to agility research, empirical approaches in the anticipation literature have tended to use response accuracy measures, which only require participants to predict an event outcome without requisite actions (van der Kamp, Rivas, van Doorn & Savelsbergh, 2008). Recent evidence has suggested the need to move away from judgement measures of anticipation, with a focus on real-time action responses (Navia, Avilés, López, & Ruiz, 2018), which has motivated new paradigms in the study of anticipation (Navia, Dicks, van der Kamp, & Ruiz, 2017). A significant consideration when research perspectives shift to the study of real-time anticipation, is how experts control the timing of action so that they arrive in the right time at the right place (van der Kamp, Dicks, Navia & Noël, 2018). There is some indication that moving later may improve performance in anticipation tasks because this allows performers to couple their movements to more reliable information (van der Kamp et al., 2018). For instance, in soccer, Dicks, Button, and Davids (2010) revealed that penalty takers' use of deception ensures that if goalkeepers couple their diving movements to early kinematic information (e.g., approach angle), which is incongruent with kick direction, this leads to decreases in response accuracy. However, if goalkeepers attend to kinematic information (e.g., non-kicking foot placement) that unfolds when the penalty taker is approximately 1.2m from the ball, this increases the likelihood of success when facing deceptive kicks. Further, in rugby, skilled players who were found to wait significantly longer than novices before initiating movement in a 1 vs. 1 anticipation task, coupled their movements to the dynamics of "honest" biological motion information (centre of mass) and performed significantly better than novices who directed their attention towards "deceptive" movements (upper trunk and out-foot placement) (Brault, Bideau, Kulpa, & Craig, 2012).

The findings of Brault et al. (2012) are corroborated by penalty kick research, which has revealed that the COD ability of soccer goalkeepers was significantly correlated to their initiation of movement. Specifically, goalkeepers with better COD ability initiated later movement responses and saved more penalty kicks (Dicks, Davids, & Button, 2010), which suggests that action capabilities such as; COD ability, speed, acceleration and power, appear to contribute to anticipatory performance. Therefore, enhancing COD ability could lead to performance improvements as a consequence of changes in the information-movement couplings underpinning anticipation (Brault et al., 2012; Dicks, Davids, et al., 2010). Adaptation to changes in abilities such as COD ability entails a process of perceptual-motor (re)calibration, where changes in action capabilities are tuned or scaled to informational variables in the environment (Brand & de Oliveira, 2017). There is, however, a paucity of research that has systematically manipulated action capabilities to assess how this affects the perception and action processes of skilled athletes in anticipation tasks. It is therefore important to identify training methods that can promote improvements in specific COD abilities to facilitate improvements in anticipation. There has been recent notable interventions aimed at developing perception-action skills such as decision-making and visual exploratory activity in out-field skilled youth soccer players (Oppici, Panchuk, Serpiello & Farrow, 2018; Pocock, Dicks, Thelwell, Chapman & Barker, 2017). In line with such efforts, this study will tailor training interventions specific to skilled out-field youth soccer players with an aim of enhancing action capabilities and anticipation performance.

Plyometric training is one method commonly prescribed to enhance action capabilities (Moran et al., 2017; Pienaar & Coetzee, 2013; Thomas, French, & Hayes, 2009). Plyometric techniques utilise the stretch-shortening cycle (SSC) of the muscle and are used to improve muscle force and power (Moran et al., 2017; Pienaar & Coetzee, 2013; Thomas et al., 2009). This technique has been used to enhance the action capabilities of youth rugby players

(Pienaar & Coetzee, 2013), hockey players (Moran et al., 2017) and soccer players (Thomas et al., 2009). An alternative training modality that has been used to enhance action capabilities is small-sided games (SSGs), which have also become a popular training method for many team sports because they have the potential to develop physiological fitness alongside technical components of performance (Chaouachi et al., 2014; Dello Iacono, Ardigo, Meckel, & Padulo, 2016; Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011; Impellizzeri et al., 2006; Young & Rogers, 2014). Moreover, through variation of pitch dimensions, player numbers and rules, SSGs possess the potential to simulate match situations, which may develop game-specific decision-making in soccer (Young & Rogers, 2014). However, in contrast to plyometric training interventions, limited research exists on the use of SSGs to enhance soccer-specific aspects of agility and associated action capabilities.

The purpose of the current study was to determine the effectiveness of plyometric and SSG training interventions in enhancing anticipation and specific action capabilities of skilled youth soccer players. The study aimed to establish if either intervention enhanced action capabilities and identify whether any of the measured abilities correlated with movement initiation in a soccer-specific anticipation test. It was hypothesised that, if correlated, improvements in these action capabilities would result in a later movement response (Dicks, Davids, et al., 2010).

Method

Participants

Twenty skilled youth soccer players from a professional soccer club participated in the study. Ethical approval was obtained from the local University ethics committee prior to the study commencing. Prior to participation, parents provided written consent for their child to participate in the study. Goalkeepers were excluded from participation, players were all male and free from musculoskeletal injury. Following the requirements of the club, participants within the COD group were part of the club's academy under 13's squad (*n* = 10, *age* = 13.13 years, *SD* = 0.38 years, *stature* = 157.05 cm, *SD* = 6.95 cm, *mass* = 45.62 kg, *SD* = 6.02 kg) and participants within the SSG group were part of the club's academy under 14's squad (*n* = 10, *age* = 14.16 years, *SD* = 0.34 years , *stature* = 172.67 cm, *SD* = 4.39 cm, *mass* = 59.77 kg, *SD* = 4.05 kg). For their respective age groups, two attacking players (one from each squad) were recruited to play the part of the attacking player in the soccer anticipation test.

Procedures

Testing procedures during the pre-test and post-test were identical. The CMVJ (Keiner, Sander, Wirth, & Schmidtbleicher, 2014) was utilised to assess dynamic leg power (Optojump, Woodway, USA), 20 m sprint (Thomas et al., 2009), with a 5-m split was used to assess acceleration (Brower Timing Systems, Utah, USA). The arrowhead COD test (Paul et al., 2016) was administered to assess the pre-planned COD capabilities of the participants (Brower Timing Systems, Utah, USA). Following this initial phase of testing, the participants were tested via a soccer-specific anticipation test (SSAT). The study took place in the closing weeks of the competitive season and both training interventions were in addition to the players' regular training.

Soccer-Specific Anticipation Test (SSAT). This test required the participants to anticipate the actions of an opposing attacking player and intercept a pass that was directed towards either a left or right destination box. The centre of both boxes were approximately 5 m from the pass point and approximately 5 m from the participant's initiation point. The test consisted of three stages: warm-up, familiarisation, and test. The ten-minute warm-up included the academy team's standardised dynamic stretching procedure, short sprints and pre-planned COD drills. Prior to undertaking the SSAT, all participants underwent a process of familiarisation, which consisted of twelve randomised left or right passes (Hopwood, Mann, Farrow, & Nielsen, 2011). This helped ensure a consistent and reliable performance from the attacking player (ball-passer), in terms of pass-direction and ball-speed. In order to ensure test reliability, both attackers were instructed not to use deception or disguise and they demonstrated consistent ball-speed pre and post-intervention (CODG [M = 4.51m/s & 4.67 m/s, SE = .21, $t(6)$ = - .62, p > .05, r = .07] and [SSGG M = 5.88 m/s & 5.53 m/s, SE = .17, $t(8)$ = 1.49, p > .05, r = .30]).

Instructions were given to the attacker prior to the test; start five metres behind the pass box and wait for a hand signal from the lead investigator identifying the desired direction of the pass, then dribble the ball into the centre of the pass box and pass the ball towards the required pass direction. When the attacker began to dribble towards the pass box, participants were instructed to run into the centre of the response box and anticipate the direction of the pass as they would in a game situation (see Figure 1). At no stage throughout testing was it possible for the participants to have prior knowledge of pass direction. The test consisted of eight randomised trials of either left (four) or right (four) passes. All trials were recorded at 120 Hz (IPad Air, California, USA) and initiation movement time (IMT) analysed via Quintic sports analysis software (West Midlands, UK).

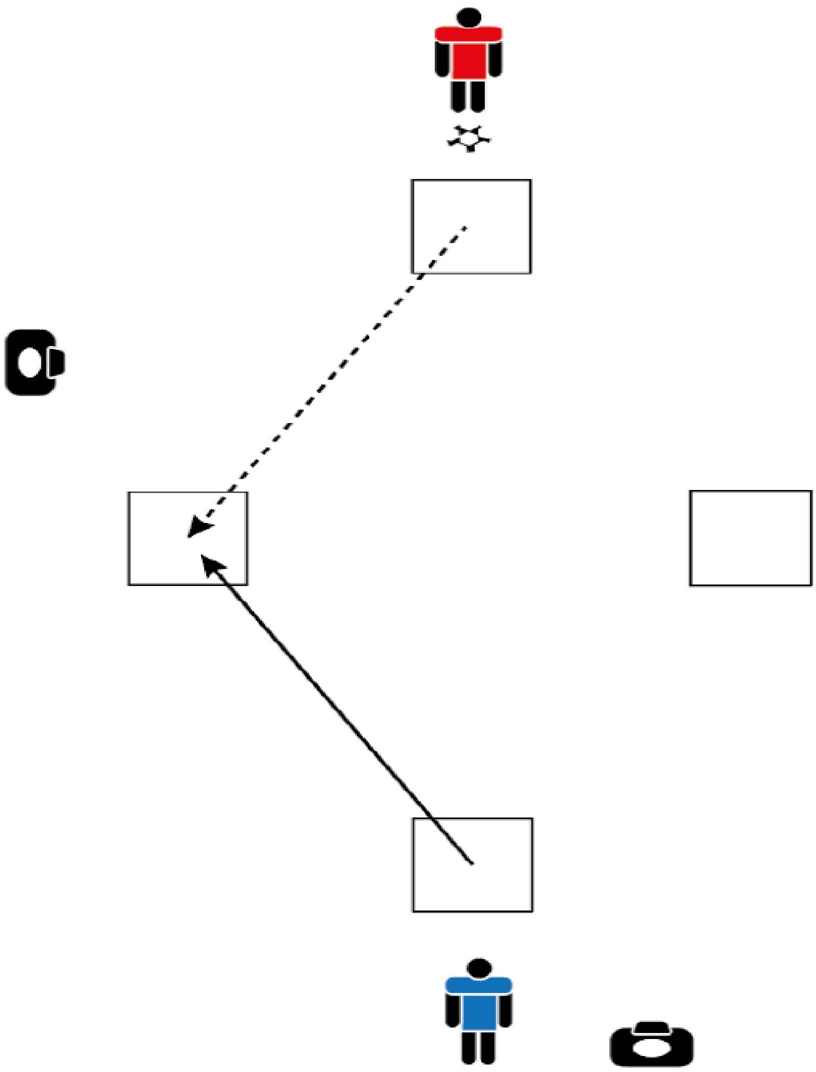

Figure 1. Soccer-Specific Anticipation Test (SSAT). Red Player Represents Attacker, with Dotted Line Representing Ball Direction. Blue Player Represents Participant, with Full Line Representing Running Direction. Horizontal Camera Tracked Initiation Movement Time (IMT) and Vertical Camera Tracked Ball Speed (BS).

Interventions

Change of Direction Intervention. Twelve Plyometric training sessions- hopping, jumping and bounding exercises were planned over a six-week period (Thomas et al., 2009). However, due to scenarios occurring beyond the control of the investigation team, this was reduced to eight sessions over a six-week period (Table 1). Prior to all sessions, a ten-minute warm-up was conducted, which included the academy's standardised dynamic stretching procedure, short sprints and pre-planned COD drills. The plyometric exercises included bilateral countermovement jumps, in addition to bilateral and unilateral hopping and bounding exercises (Thomas et al., 2009). All exercises were equivalent to training conditions previously encountered by the participants. Therefore, a minimal process of familiarisation was required. Participants were instructed to minimise ground-contact time while maximizing height or distance.

Table 1. Change of Direction Group's Plyometric Intervention.

	Session 1	**Session 2**
Week 1 (100 Contacts)	Tuck Jumps (x 5) Split Jumps (x 10) Squat Jumps (x 5) DL Broad Jumps (x 5) SL Broad Jumps (x 5 EL) CMVJ (x 5)	Squat Jumps (x 10) DL Broad Jumps (x 10)
Week 2 (120 Contacts)	CMVJ (x 10) Tuck Jumps (x 5) DL Broad Jumps (x 5) Bounding (x 5 EL) SL Broad Jumps (x 5 EL) SL Hops (x 5 EL)	Squat Jumps (x 10) CMVJ (x 10) Bounding (x 5 EL)
Week 3		
Week 4 (140 Contacts)	CMVJ (x 10) Tuck Jumps (x 5) DL Broad Jumps (x 10) SL Broad Jumps (x 5 EL)	Bounding (x 10 EL) CMVJ (x 10) Squat Jumps (x 10)

	SL Hops For Distance (x 5 EL) Bounding (x 5 EL)	
Week 5		
Week 6 (160 Contacts)	CMVJ (x 10) Tuck Jumps (x 10) DL Broad Jumps (x 10) Bounding (x 5 EL) SL Broad Jumps (x 5 EL) SL Hops (x 5 EL)	Bounding (x 15 EL) Squat Jumps (x 10) CMVJ (x 10)
Abbreviations: DL = double-leg, SL = single-leg, CMVJ = countermovement vertical jump *Note.* Rest 10 s between each repetition and 90 s recovery between each exercise.		

Small-Sided Games Intervention. Eight SSGs sessions were undertaken over a six-week period, comprising 1 v 1, 2 v 2 and 3 v 3 games played on 10 x 20, 20 x 20 and 20 x 30 m 3G playing surface, respectively (Impellizzeri et al., 2006; Young & Rogers, 2014). Prior to all sessions, the academy's standardised warm-up procedure was undertaken. The exercise intensity of SSGs compares with exercise intensity of competitive match play and include variables such as decelerations, changes of direction, backwards running, jumping and sprinting (Hill-Haas, Dawson, Impellizzeri, & Coutts, 2011). Thus, creating a rationale as a suitable intervention to improve the aforementioned action capabilities. Small-sided games were representative of the training that the players might undertake in typical training, however the implementation of this mode of practice had not previously been structured in a systematic manner as carried out in the current experiment. For instance, to promote player's game involvement and COD frequency, no goalkeepers participated in this intervention.

Game durations were in one minute bouts, with the same recovery period (1:1 exercise to rest ratio).

Dependent Measures. For the SSAT, IMT was defined as the time between the attacker's foot connecting with the ball to pass to the desired destination box, until the participant planted their outside foot to initiate a change of direction (Young & Rogers, 2014). A positive value was recorded if the moment of initiation occurred after foot-ball contact and a negative value was recorded if initiation occurred before foot-ball contact. Further, as highlighted in the Procedures section above, action capabilities were measured using the following four tests: (i) CMVJ test; (ii) 20-m sprint test; (iii) a 5-m acceleration test; and (iv) the arrowhead COD test.

Statistical Analysis

Due to injuries and player release, only 14 players (CODG, N = 6; SSGG, N = 8) completed the training intervention and post-test procedures. Performance on the SSAT and all physical abilities were assessed using a 2 Group (SSGG, CODG) x 2 Test Sessions (Pre, Post) design. Pre-test analyses highlighted differences between the two groups for three of the four physical tests, therefore between-subject (Group) and within-subject (Test) effects were analysed separately. Normality was assessed with Shapiro-Wilk tests and for the CMVJ, 20-m sprint, 5-m acceleration and the arrowhead COD tests, assumptions for parametric testing were met. Paired-samples t-tests were conducted to compare within-subject effects between pre- and post-intervention across all participants. To examine between-subject effects, Δ change was analysed using independent t-tests to compare between the CODG and the SSGG. Assumptions for parametric testing were not met for the IMT data therefore, to establish differences in IMT between pre and-post interventions, a Wilcoxon-signed-rank test was conducted. To establish the relationship between physical capabilities and IMT, Spearman correlation tests were carried out. Significance was accepted at $p \leq .05$ for all statistical tests and effect sizes are reported as Pearson's correlation coefficient *(r).* Effect sizes are interpreted according to Cohen's (1992) recommendations; small (0.1), moderate (0.3) and large (0.5). Finally, individual-level analyses are also reported in order to capture variations in physical abilities and anticipatory performance (Dicks, Davids et al., 2010; Muller et al., 2017).

Results

Pre-Intervention Baseline Performance

Independent t-tests revealed that the SSGG performed better than the CODG in the CMVJ test (M = 19.17 ± 0.53 cm; M = 18.21 ± 2.11 cm), sprint test (M = 3.27 ± .16 s; M = 3.39 ± .09 s) and the COD test (M = 17.46 ± .60 s; M = 17.51 ± .47 s) at baseline. These differences were also significant (t (18) = -4.39, p < .05, r = .51; t (18) = 3.75, p < .05, r = .43; t (18) = 3.36, p < .05, r = .38, respectively). There were no significant (t (18) = 1.81, p > .05, r = .15) differences in acceleration between the SSGG (M = 1.09 ± .05 s) and the CODG (M = 1.09 ± .02 s), respectively. Further, the SSGG (Mdn = 0.06 s) initiated movement significantly later than the CODG (Mdn = -0.05 s), T = 7, p <. 05, r = .44.

Pre-Intervention to Post-Intervention, Within-Subject Effects:

Individual-level data for performance on the action capability tests and soccer-specific anticipation test are presented in Tables 2 – 3.

Table 2. Mean Performance Results of the Change of Direction Group (CODG) Pre- and Post-Intervention.

Participant	CMVJ (cm)		5 M (s)		20 M (s)		COD (s)		IMT (s)	
	PRE	**POST**	**PRE**	**POST**	**PRE**	**POST**	**PRE**	**POST**	**PRE**	**POST**
CODG 1	16.7	17.2*	1.14	1.2	3.56	3.60	18.32	18.3*	-0.79 ± 0.12	-0.05 ± 0.13
CODG 2	18.2	21.8*	1.14	1.19	3.39	3.34	17.17	17.76	-0.08 ± 0.07	0.04 ± 0.07**
CODG 3	16.9	18.5*	1.06	1.06	3.34	3.24*	17.76	17.7*	-0.11 ± 0.12	-0.16 ± 0.15
CODG 4	16.9	17.7*	1.17	1.15*	3.41	3.40*	17.70	17.9	.083 ± 0.14	0.05 ± 0.11
CODG 5	22.8	24.3*	1.12	1.10*	3.26	3.25*	16.85	16.74*	-0.02 ± 0.16	0.147 ± 0.11***
CODG 6	17.8	19.6*	1.09	1.08*	3.39	3.36*	17.26	17.21*	-0.12 ± 0.16	-0.03 ± 0.19
Mean ± SD	18.21 ± 2.11	19.85 ± 2.48	1.09 ± 0.02	1.13 ± 0.05	3.39 ± 0.09	3.36 ± 0.11	17.51 ± 0.47	17.60 ± 0.50	-0.05 ± 0.28	-0.01 ± 0.09

Abbreviations: CMVJ = countermovement vertical jump; 5 M = 5 metre acceleration; 20 M = 20 metre sprint; COD = arrowhead change of direction test; PRE = pre-intervention; POST = post-intervention; CODG 1-CODG 6 = participants

Note: * Performance improvements post-intervention

Note IMT: 0 s equal to when the ball is passed by the attacker; values are reported as mean ± SD, **small effect, ***moderate effect.

Table 3. Mean Performance Results of the Small-Sided Games Group (SSGG) Pre- and Post-Intervention.

Participant	CMVJ (cm)		5 M (s)		20 M (s)		COD (s)		IMT (s)	
	PRE	POST	PRE	POST	PRE	POST	PRE	POST	PRE	POST
SSGG 1	19.2	20.5*	1.16	1.16	3.48	3.50	18.21	18.20*	-0.14 ± 0.18	-0.13 ± 0.16
SSGG 2	21.6	22.8*	1.10	1.04*	3.20	3.21	17.20	17.28	-0.10 ± 0.08	0.04 ± 0.10**
SSGG 3	19.5	20.4*	1.19	1.28	3.53	3.53	18.40	18.39*	0.06 ± 0.10	0.68 ± 0.24
SSGG 4	19.7	20.9*	1.04	1.07	3.24	3.23*	16.55	16.53*	.042 ± 0.11	0.25 ± 0.19***
SSGG 5	18.3	17.2	1.12	1.12	3.33	3.21*	17.57	17.37*	0.02 ± 0.17	-0.02 ± 0.08
SSGG 6	21.8	22.3*	1.03	1.04	3.24	3.32*	17.15	17.23	-0.02 ± 0.12	-0.05 ± 0.16
SSGG 7	19.3	19.1	1.06	1.04*	3.06	3.18	17.49	17.28*	.06 ± 0.13	-0.02 ± 0.11
SSGG 8	21.6	24.5*	1.09	1.10	3.14	3.10*	17.17	17.01*	0.08 ± 0.61	0.12 ± 0.09
Mean ± SD	19.17 ± 0.53	20.96 ± 2.11	1.09 ± 0.05	1.10 ± 0.07	3.27 ± 0.15	3.28 ± 0.14	17.46 ± 0.56	17.41 ± 0.56	0.06 ± 0.07	0.10 ± 0.24

Abbreviations: CMVJ = countermovement vertical jump; 5 M = 5 metre acceleration; 20 M = 20 metre sprint; COD = arrowhead change of direction test; PRE = pre-intervention; POST = post-intervention; SSGG 1-SSGG 8 = participants

Note: * Performance improvements post-intervention

Note IMT: 0 s equal to when the ball is passed by the attacker; values are reported as mean ± SD, **small effect, ***moderate effect.

2

Δ Change Between-Group Effects;

There were no significant differences in Δ change between the CODG and the SSGG in their effectiveness of enhancing sprint capability (t (12) = .69, p >.05, r = .03), acceleration (t (12) = -.11, p >.05, r = .00) and COD ability (t (12) = -1.12, p >.05, r = .09). Although a non-significant, small effect size indicated that the CODG marginally improved CMVJ in comparison with SSGG (t (12) = 1.29, p >.05, r = .12). There were no significant differences in Δ change IMT between the CODG and the SSGG (T = 29, p >. 05, r = .11).

The Relationship between Action Capabilities and IMT;

In order to study global relationships between IMT and the different action capability tests conducted, we examined the relationship between these respective variables and the performance of all players, irrespective of training group. Analysis of the CMVJ and IMT post-intervention revealed a significant correlation between these two measures r = .61, p < .05 (see Figures 2 and 3). Specifically, the increase in CMVJ was correlated with IMT post-intervention. There were no significant correlations between pre-intervention IMT and any of the action capabilities at this testing phase (CMVJ: r = .41, p = .14; 5 m acceleration: r = .03, p = .92; 20 m sprint: r = - .47, p = .09; and COD: r = -.37, p = .19), nor were there any other significant correlations between post-intervention IMT and any of the other physical variables (5 m acceleration: r = -.04, p = .88; 20 m sprint: r = -.24, p = .41; and COD: r = -.51, p = .06).

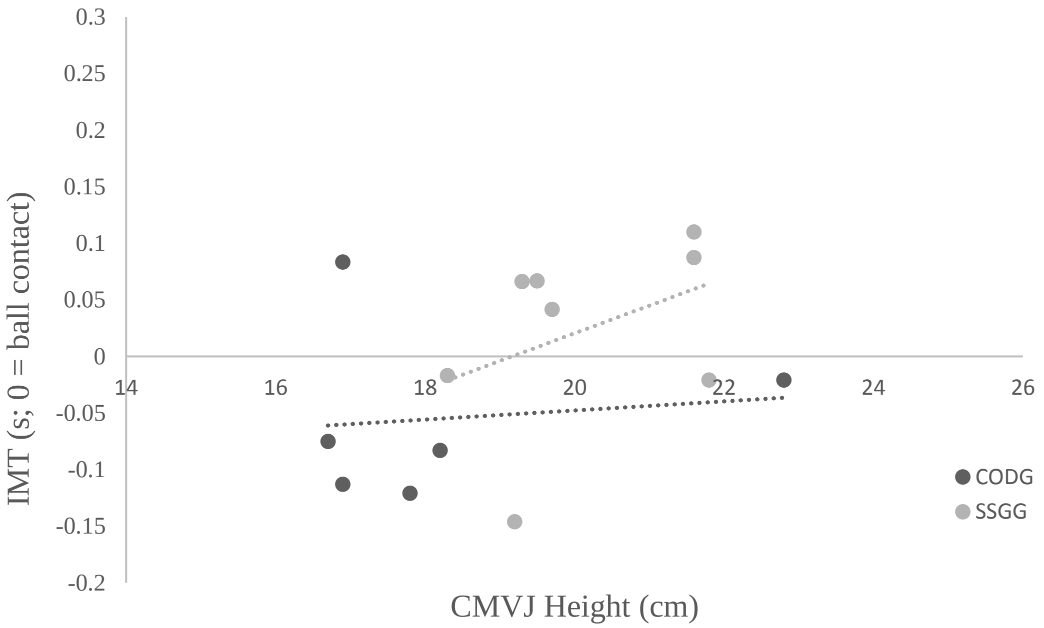

Figure 2. Initiation Movement Time and Countermovement Vertical Jump Relationship Pre-Intervention for the Change of Direction (CODG) and the Small Sided Games (SSGG) groups.

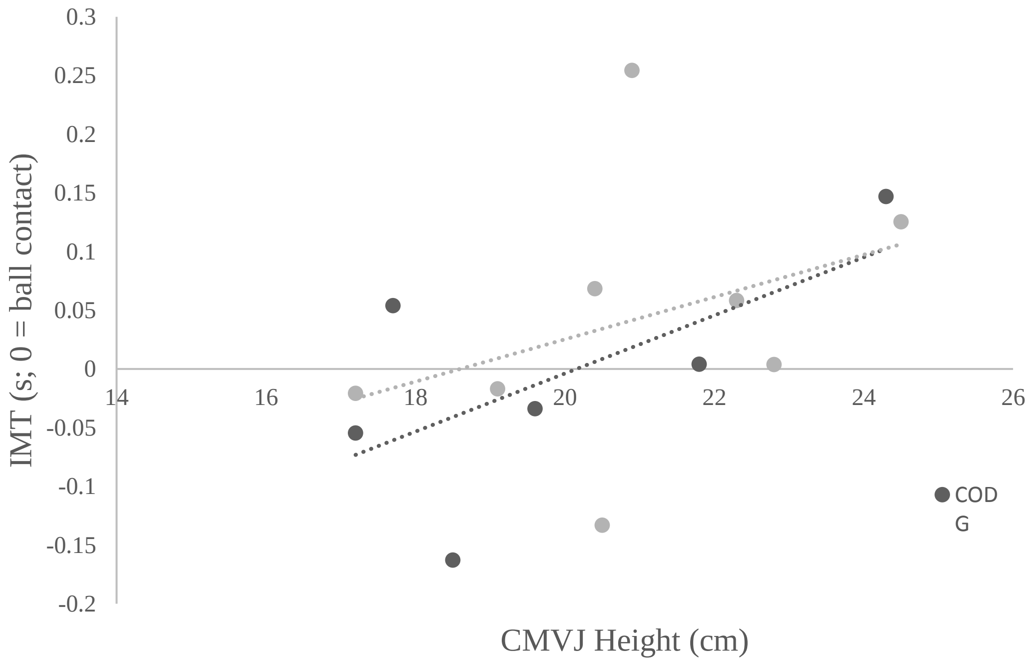

Figure 3. Initiation Movement Time and Countermovement Vertical Jump Relationship Post-Intervention for the Change of Direction (CODG) and the Small Sided Games (SSGG) groups

Individual Differences;

Observation of individual-level data indicates some variation in training responses relative to both the action capabilities and performance on the SSAT. Two participants in the CODG (CODG 5 & CODG 6) showed improvements in all physical performance tests and this was associated with a later IMT post-intervention (see Table 2). No participants in the SSGG demonstrated improvements in all physical performance tests but participants SSGG 4 and SSGG 8 showed improvements in 3 out of the 4 physical performance variables, with SSGG also producing a later IMT post-intervention (see Table 3).

Discussion

The purpose of the current study was two-fold: (i) to examine whether a small-sided game intervention and a plyometric change of direction training intervention elicited changes in action capabilities; and (ii) to ascertain whether action capabilities were correlated with performance on a soccer specific anticipation test. It was hypothesised that improvements in physical capabilities would result in a later movement response in the anticipation test (Dicks, Davids et al., 2010). Results revealed a significant improvement in CMVJ performance in the post-test in comparison with the pre-test although there was no Δ change between-groups. Despite there being no correlation between action capabilities and movement time in the pre-test, post-test analysis revealed that the significant increase in CMVJ height was correlated with movement time.

This finding indicates possible support for the work of Dicks, Davids et al. (2010) in highlighting a correlation between physical capability and movement initiation time. Following the six-week training interventions, both groups significantly improved CMVJ height, which indicate that adaptations relating to increases in leg power occurred (Thomas et al., 2009). Jump height is commonly used as a surrogate field measure of power. Therefore, it would appear that power improvements in the current study may have underpinned movement initiation. Previous research has revealed that during real-time anticipation tasks, experts have been shown to produce later movement times (e.g., Brault et al., 2012), which are thought to enable players to rely on later more, useful biological motion of an opponent (Navia et al., 2017). Future work is needed to better understand the relationship between action capabilities and anticipation performance in order to identify the association between the perceptual-motor system and information pick-up underpinning skilled sport performance (Brand & de Oliveira, 2017; van der Kamp et al., 2018).

Specific to the SSGG, there were adaptations relating to increases in leg power, as gains in CMVJ height were observed (4%). These findings are comparable with a 5.6% increase in CMVJ height that have been previously reported (Dello Iacono et al., 2016). The CMVJ test protocol of the present study involved an explosive, bilateral, triple extension movement, which has direct stretch-shortening cycle contributions (Thomas et al., 2009). SSGs are characterised by un-planned COD tasks and short-sprints. These tasks mainly rely on rapid acceleration, deceleration transitions, which also have direct stretch-shortening cycle contributions. Therefore, it appears as though stretch-shortening cycle adaptations may have elicited meaningful improvements in CMVJ height. Analysis of the CODG performance revealed no meaningful Δ change in speed and acceleration. These findings support studies that have shown no improvements in sprint-speed following a period of plyometric training (Negrete & Brophy, 2000; Thomas et al., 2009). Thomas et al. (2009) suggested that the lack of improvements in sprint-speed may be a result of plyometric exercises not eliciting short enough ground-contact times, which generate explosive ground reaction forces during sprinting. Moreover, the SSGG intervention did not elicit meaningful Δ change improvements in speed and acceleration. This latter finding was surprising given the relationship between vertical jump height and short-duration sprint performance (Chamari et al., 2004).

Although collective analysis reported non-significant improvements in COD ability post-intervention, individual-level analyses indicated that the plyometric intervention undertaken by the CODG elicited small improvements in COD ability for some participants. In contrast to sprinting, COD ability involves greater emphasis on the adaptive coupling of acceleration and deceleration, and leg muscle power has been moderately correlated with COD ability (Negrete & Brophy, 2000; Thomas et al., 2009; Young, Miller, & Talpey, 2015). The CMVJ improvements evident in the two participants, led to later movement responses in the SSAT (Brault et al., 2012; Dicks, Davids, et al., 2010). Unlike the SSGG intervention, the plyometric training method of the CODG did not encompass any game-specific anticipatory processes, which may raise some doubt towards the notion that game-specific anticipatory skill may only be enhanced if learning conditions are representative of the performance environment (Pinder, Davids, Renshaw, & Araujo, 2011). However, it is possible that players within CODG were given sufficient opportunity to calibrate their enhanced action capabilities to the performance environment as they undertook regular on-field training throughout the intervention (see also, Hopwood et al. 2011). The CODG of the present study were not exposed to extra game-specific scenarios but the majority of players within that training group produced later movement responses post-intervention. Training programs that are designed to enhance speed, acceleration, power or COD ability may be a suitable method of enhancing anticipation. However, the value of such methods in isolation, without the exposure to performance environment situations is yet to be confirmed. To further this applied science project conducted within the constraints of a professional soccer team, future research would benefit from a study design, which includes a physical training only group, physical training in addition to game-based activities group and a game-based activities only group.

The findings of the present study provide some support to the studies that have highlighted the efficacy of SSGs in improving physiological fitness components (Chaouachi et al., 2014; Hill-Haas et al., 2011; Impellizzeri et al., 2006; Young & Rogers, 2014). Individual improvements were observed in COD ability post-intervention, with SSGG 5 demonstrating the highest improvement (1.2%). This magnitude of improvement is consistent with previous research findings (Hill-Haas et al., 2011; Impellizzeri et al., 2006) but these performance improvements are not as profound as the 7.8% observed in skilled male handball players, following a SSGs intervention (Dello Iacono et al., 2016). The disparity in these findings may be a result of the longer (eight weeks), uninterrupted intervention that was conducted by Dello Iacono et al. (2016). Nevertheless, collective findings suggest that SSGs may provide a sufficient training stimulus to promote relevant adaptations in COD ability-related variables.

The SSAT encompassed an opposing player, which enabled participants to respond to game specific actions (Navia et al., 2017). In order to ensure the repeatability of the SSAT between pre- and post-tests, the attacking players followed a test-script and did not utilise deceptive actions (see Dicks, Button et al., 2010). However, in turn, this may have led to a potential limitation in the present study. Following the familiarisation process and pre-tests, participants may have assessed the possibilities of being deceived, and established that the risks of moving early were not equivalent to the risks of moving early during a game-based scenario, leading to a response bias. Canal-Bruland and Schmidt (2009) revealed that skilled handball goalkeepers were significantly biased to judge handball penalty shot movements as deceptive, whereas skilled field players nor novices showed this response bias. Although the enhanced action capability (CMVJ) did not lead to a significantly later IMT in the current study, it is possible that the participant's awareness of the limited risks that accompanied an early response, may have resulted in the participants moving earlier. Future work in the agility literature would benefit from the inclusion of deception to better understand how (inter)actions are controlled in sport-specific tests of the anticipatory processes underpinning this aspect of skill (Dicks, Button et al., 2010; Paul et al., 2016).

Due to the participant recruitment policy imposed by the professional club, training groups were assigned based on age group status. The CODG participants were recruited from within the academy's U13s squad and the SSGG participants were recruited from the U14s squad. As can be explained by differences in maturation and growth between the two training groups (Portas, Parkin, Roberts & Batterham, 2016), the SSGG achieved better results than the CODG pre- and post-intervention, in CMVJ, speed, acceleration and COD ability. Moreover, observation of IMT in both groups, revealed that the CODG initiated earlier movement responses than the SSGG in the SSAT. The SSGG seemed to have the physical capabilities to initiate a later response, perhaps exploiting specifying variables including ball flight information and more reliable, non-specifying variables such as the orientation of the non-kicking foot (Dicks, Davids, et al., 2010; van der Kamp et al., 2018).

Conclusion

The present study may be the first intervention study to examine the relationship between action capabilities and the movement initiation in an anticipation task. Significant improvements were observed in CMVJ performance following training for SSGG and CODG, and this action capability correlated with IMT in the anticipation task. Collective analysis of both training groups did not identify improvements in sprint, acceleration and COD ability performance. Nevertheless, individual-level analysis indicated that both training interventions may be suitable methods of improving physical performance variables. These analyses identify that physical improvements and adjustments in anticipation may be masked by grouping and averaging data. Therefore, future perception and action training studies may be best served highlighting and presenting individual differences (Dicks, Button, Davids, Chow & van der Kamp, 2017). Moreover, many aspects of the present study highlight the need for further investigation of the relationship between anticipation and agility. The majority of agility research has focussed predominantly on the physical elements of agility but there now seems to be an ever-growing appreciation of the perceptual-motor demands of this ability (Paul et al., 2016).

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References

Abernethy, B., Gill, D. P., Parks, S. L., & Packer, S. T. (2001). Expertise and the perception of kinematic and situational probability information. *Perception*, *30*(2), 233-252.

Brand, M. T., & de Oliveira, R. F. (2017). Recalibration in functional perceptual-motor tasks: A systematic review. *Human Movement Science, 56*, 54-70. doi:10.1016/j.humov.2017.10.020

Brault, S., Bideau, B., Kulpa, R., & Craig, C. M. (2012). Detecting Deception in Movement: The Case of the Side-Step in Rugby. *Plos One, 7*(6). doi:ARTNe3749410.1371/journal.pone.0037494

Canal-Bruland, R., & Schmidt, M. (2009). Response bias in judging deceptive movements. *Acta Psychol (Amst), 130*(3), 235-240. doi:10.1016/j.actpsy.2008.12.009

Chamari, K., Hachana, Y., Ahmed, Y. B., Galy, O., Sghaier, F., Chatard, J. C., . . . Wisloff, U. (2004). Field and laboratory testing in young elite soccer players. *Br J Sports Med, 38*(2), 191-196.

Chaouachi, A., Chtara, M., Hammami, R., Chtara, H., Turki, O., & Castagna, C. (2014). Multidirectional sprints and small-sided games training effect on agility and change of direction abilities in youth soccer. *Journal of Strength and Conditioning Research, 28*(11), 3121-3127. doi:10.1519/JSC.0000000000000505

Dello Iacono, A., Ardigo, L. P., Meckel, Y., & Padulo, J. (2016). Effect of Small-Sided Games and Repeated Shuffle Sprint Training on Physical Performance in Elite Handball Players. *Journal of Strength and Conditioning Research, 30*(3), 830-840. doi:10.1519/JSC.0000000000001139

Dicks, M., Button, C., & Davids, K. (2010). Examination of gaze behaviors under in situ and video simulation task constraints reveals differences in information pickup for perception and action. *Atten Percept Psychophys, 72*(3), 706-720. doi:10.3758/APP.72.3.706

Dicks, M., Button, C., Davids, K., Chow, J. Y., & Van der Kamp, J. (2017). Keeping an eye on noisy movements: On different approaches to perceptual-motor skill research and training. *Sports Medicine*, *47*(4), 575-581.

Dicks, M., Davids, K., & Button, C. (2010). Individual differences in the visual control of intercepting a penalty kick in association football. *Human Movement Science, 29*(3), 401-411. doi:10.1016/j.humov.2010.02.008

Fajen, B. R., Riley, M. A., & Turvey, M. T. (2009). Information, affordances, and the control of action in sport. *International Journal of Sport Psychology, 40*(1), 79-107

Gabbett, T. J., Kelly, J. N., & Sheppard, J. M. (2008). Speed, change of direction speed, and reactive agility of rugby league players. *Journal of Strength and Conditioning Research, 22*(1), 174-181. doi:10.1519/JSC.0b013e31815ef700

Hill-Haas, S. V., Dawson, B., Impellizzeri, F. M., & Coutts, A. J. (2011). Physiology of small-sided games training in football: a systematic review. *Sports Med, 41*(3), 199-220. doi:10.2165/11539740-000000000-00000

Hopwood, M. J., Mann, D. L., Farrow, D., & Nielsen, T. (2011). Does Visual-Perceptual Training Augment the Fielding Performance of Skilled Cricketers? *International Journal of Sports Science & Coaching, 6*(4), 523-535. doi:10.1260/1747-9541.6.4.523

Impellizzeri, F. M., Marcora, S. M., Castagna, C., Reilly, T., Sassi, A., Iaia, F. M., & Rampinini, E. (2006). Physiological and performance effects of generic versus specific aerobic training in soccer players. *International Journal of Sports Medicine, 27*(6), 483-492. doi:10.1055/s-2005-865839

Keiner, M., Sander, A., Wirth, K., & Schmidtbleicher, D. (2014). Long-Term Strength Training Effects on Change-of-Direction Sprint Performance. *Journal of Strength and Conditioning Research, 28*(1), 223-231. doi:10.1519/JSC.0b013e318295644b

Mann, D. L., Abernethy, B., & Farrow, D. (2010). Action specificity increases anticipatory performance and the expert advantage in natural interceptive tasks. *Acta Psychol (Amst), 135*(1), 17-23. doi:10.1016/j.actpsy.2010.04.006

Matavulj, D., Kukolj, M., Ugarkovic, D., Tihanyi, J., & Jaric, S. (2001). Effects of plyometric training on jumping performance in junior basketball players. *J Sports Med Phys Fitness, 41*(2), 159-164.

Moran, J., Sandercock, G. R. H., Ramirez-Campillo, R., Todd, O., Collison, J., & Parry, D. A. (2017). Maturation-Related Effect of Low-Dose Plyometric Training on Performance in Youth Hockey Players. *Pediatr Exerc Sci, 29*(2), 194-202. doi:10.1123/pes.2016-0151

Morland, B., Bottoms, L., Sinclair, J., & Bourne, N. (2013). Can Change of Direction Speed and Reactive Agility Differentiate Female Hockey Players? *International Journal of Performance Analysis in Sport, 13*(2), 510-521.

Navia, J. A., Dicks, M., van der Kamp, J., & Ruiz, L. M. (2017). Gaze control during interceptive actions with different spatiotemporal demands. *J Exp Psychol Hum Percept Perform, 43*(4), 783-793. doi:10.1037/xhp0000347

Navia, J. A., Avilés, C., López, S. & Ruiz, L. M. (2018). A current approach to anticipation in sport. *Studies in Psychology, 38*, 1-19. doi: 10.1080/02109395.2017.1412705

Negrete, R., & Brophy, J. (2000). The relationship between isokinetic open and closed chain lower extremity strength and functional performance. *Journal of Sport Rehabilitation, 9*(1), 46-61.

Oppici, L., Panchuk, D., Serpiello, F. R., & Farrow, D. (2018). Futsal task constraints promote transfer of passing skill to soccer task constraints. European Journal of Sport Science, 18(7), 947-954, doi:10.1080/17461391.2018.1467490Paul, D. J., & Akenhead, R. (2018). Agility Training: A Potential Model for the Reduction and Rehabilitation of Anterior Cruciate Ligament Injury. *Strength & Conditioning Journal, 40*(1), 98-105.

Paul, D. J., Gabbett, T. J., & Nassis, G. P. (2016). Agility in Team Sports: Testing, Training and Factors Affecting Performance. *Sports Medicine, 46*(3), 421-442. doi:10.1007/s40279-015-0428-2

Pienaar, C., & Coetzee, B. (2013). Changes in selected physical, motor performance and anthropometric components of university-level rugby players after one microcycle of a combined rugby conditioning and plyometric training program. *Journal of Strength and Conditioning Research, 27*(2), 398-415. doi:10.1519/JSC.0b013e31825770ea

Pinder, R. A., Davids, K., Renshaw, I., & Araujo, D. (2011). Representative Learning Design and Functionality of Research and Practice in Sport. *Journal of Sport & Exercise Psychology, 33*(1), 146-155.

Pocock, C., Dicks, M., Thelwell, R. C., Chapman, M., & Barker, J. (2017). Using an imagery intervention to train visual exploratory activity in elite academy football players. Journal of Applied Sport Psychology, doi:10.1080/10413200.2017.1395929.

Santos, E. J., & Janeira, M. A. (2008). Effects of complex training on explosive strength in adolescent male basketball players. *Journal of Strength and Conditioning Research, 22*(3), 903-909. doi:10.1519/JSC.0b013e31816a59f2

Scanlan, A., Humphries, B., Tucker, P. S., & Dalbo, V. (2014). The influence of physical and cognitive factors on reactive agility performance in men basketball players. *Journal of Sports Sciences, 32*(4), 367-374. doi:10.1080/02640414.2013.825730

Sekulic, D., Krolo, A., Spasic, M., Uljevic, O., & Peric, M. (2014). The Development of a New Stop'n'go Reactive-Agility Test. *Journal of Strength and Conditioning Research, 28*(11), 3306-3312. doi:10.1519/Jsc.0000000000000515

Sheppard, J. M., & Young, W. B. (2006). Agility literature review: Classifications, training and testing. *Journal of Sports Sciences, 24*(9), 919-932. doi:10.1080/02640410500457109

Thomas, K., French, D., & Hayes, P. R. (2009). The Effect of Two Plyometric Training Techniques on Muscular Power and Agility in Youth Soccer Players. *Journal of Strength and Conditioning Research, 23*(1), 332-335. doi:10.1519/JSC.0b013e318183a01a

Triolet, C., Benguigui, N., Le Runigo, C., & Williams, A. M. (2013). Quantifying the nature of anticipation in professional tennis. *Journal of Sports Sciences, 31*(8), 820-830.

van der Kamp, J., Rivas, F., van Doorn, H., & Savelsbergh, G. (2008). Ventral and dorsal system contributions to visual anticipation in fast ball sports. *International Journal of Sport Psychology, 39*(2), 100-130

van der Kamp, J., Dicks, M., Navia, J. A. & Noël, B. (2018). Goalkeeping in the soccer penalty kick. *German Journal of Exercise and Sport Research, 48*(2), 169-175. doi: 10.1007/s12662-018-0506-3

Young, W., & Rogers, N. (2014). Effects of small-sided game and change-of-direction training on reactive agility and change-of-direction speed. *J Sports Sci, 32*(4), 307-314. doi:10.1080/02640414.2013.823230

Young, W. B., Miller, I. R., & Talpey, S. W. (2015). Physical qualities predict change-of-direction speed but not defensive agility in Australian rules football. *Journal of Strength and Conditioning Research, 29*(1), 206-212. doi:10.1519/JSC.0000000000000614