International Journal of Strength and Conditioning

The Effects of an In-Season Athletic Motor Skill Competencies Intervention on Bio-Motor Qualities among Sub-Elite Male Youth Soccer Players

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ABSTRACT

The aim of this study was to evaluate the efficacy of an in-season athletic motor skill competency (AMSC) programme on the physical bio-motor qualities of youth academy soccer players. Thirty-four (n = 34) U14 and U15 male underage academy soccer players were recruited from a League of Ireland (LOI) soccer club. The study was conducted over 10 weeks that included a pre-testing battery, an 8-week intervention, and a post-testing battery. Pre- to post-intervention, the U14 squad experienced significant increases in countermovement jump (CMJ) peak power, and both chin-up three repetition maximum (3RM) and predicted 1RM ($p < 0.05$, effect size [ES] = 0.15 to 0.25). The U15 squad displayed significant changes in 5m sprint time ($p < 0.05$, ES = 0.20); CMJ height, peak power, and propulsive impulse ($p < 0.05$, ES = -0.17 to -0.58). The U15 squad demonstrated a significant improvement in their 5m sprint time compared to the U14 squad ($p < 0.05$). Additionally, 38% of the U14 squad showed improvements exceeding the smallest worthwhile change (SWC) across seven CMJ variables (jump height, peak power, eccentric duration, RSI_{mod}, mean peak force, propulsive impulse, time to take-off). Similarly, 43% of the U15 squad achieved positive changes greater than the SWC in sprint speed, strength, and 5 of the jump variables. This study provides valuable evidence for integrating an AMSC programme into youth soccer training regimens to optimize player development and performance.

Keywords: athletic motor skill competencies (AMSC), youth, soccer, competitive phase, bio-motor qualities.

INTRODUCTION

Soccer is a team sport characterised by bouts of intermittent activity with a combination of technical, tactical, physical, and psychological demands (13). Among these, physical skills play a vital role in the performance of soccer players, in particular youth players (43). Total distance covered per match for youth male soccer players is age-dependent, with more distance typically covered among older squads than younger squads (1,43). Male U15 players typically cover 6.6km per match (1), while U18 and U23 players cover up to 10km per match (43). These distances are covered at various intensities and contextual speeds (1). U15 players typically cover 1840m of high-speed running and 210m of sprint distance per match (52). U15 players average 97.3 m/min and reach maximum sprint speeds of approximately 26.5 km/h, with an average sprint distance of 16m (1). Physical metrics such as high-speed running (HSR), sprint distance, and average running speed increase as players progress through the age grades (1,43). Furthermore, the physical demands of elite level soccer have increased in recent years. High intensity running actions have increased across the top leagues in nations such as England and Spain, and they are expected to increase further in the coming years (43,46). While it is suggested that the high-intensity requirements of the sport have increased, research also suggests that goal scoring opportunities are enhanced with greater sprinting speeds and sprints are the most frequent actions in goal situations (19,44). Youth soccer players must therefore possess enhanced physical bio-motor qualities to compete at the highest level of the game (12,56,57).

Motor skills are described as the broad range of movement skills that serve as building blocks for more advanced and complex movements required to participate in activities and games (34). Bio-motor skills are the complex set of movement patterns such as speed, agility, strength, power, endurance, and coordination required for physical performance (31). It is crucial that youth soccer players have the ability to produce and attenuate forces in different planes of motion during game-play. However, despite the importance of these qualities, many young soccer players struggle to develop them to their full potential, leading to suboptimal performance and increased risk of injury (53). Additional barriers for youth soccer players include sporting culture/tradition, academic pressures, training experience, and limited contact time within an academy system. Previous research suggests that developing muscular strength may transfer to improvements in bio-motor qualities (14,55). Stronger athletes can develop higher peak ground reaction forces and impulse, which may enhance physical qualities such as sprinting and jumping performance (55,58,59). These qualities are vital to develop in players due to the importance of high-intensity actions such as sprinting in soccer (20,45). Training interventions have been used to enhance muscular strength, rate of force development (RFD), impulse, and endurance, which are important bio-motor qualities for soccer players (5, 60). A recent meta-analysis by Oliver et al., (47) concluded that it is possible for positive adaptations in muscular strength, jump height, and sprint performance to be made with high level, highly trained male youth soccer players through variety of training methods. It was reported that vertical and horizontal power and sprint acceleration were the variables most likely to be improved with this population using strength, plyometric and a combination of these methods. Such results were possible even in short duration training interventions (≤ 12 weeks) (47). It has been suggested that biological maturity status impacts strength gains positively in boys during and after peak height velocity (PHV) (41). It has also been proposed that training related plyometric adaptations could explain neuro-physiological and morphological changes that occur in the muscle-tendon complex during maturation in male youth athletes (40).

While there is some evidence that strength training can improve bio-motor qualities, the effects of in-season strength training interventions on the bio-motor qualities of youth male soccer players are not yet well understood (48,59). Previous research has demonstrated that resistance training is an effective modality (ES=0.52) to enhance adolescent motor skills including jumping, running and throwing (6). The efficacy of such training interventions while playing competitive fixtures and partaking in regular technical and tactical sessions is less established. Recent research has advocated the use of Athletic Motor Skill Competencies (AMSC) as a tool to develop bio-motor qualities in youth (14,31,50). The AMSC movement patterns are parts of Fundamental Movement Skills and more sport-specific in nature (31,32). The central component to the AMSC framework is the ability to produce and attenuate forces during sports specific movements (49). The aim of the AMSC is to facilitate a balanced development of motor skills to augment athletic performance and increase preparedness for future demands of competitive sport (31). Furthermore, they aim to maximise physical performance and reduce injury risk (50). Ensuring young athletes are exposed to a wide variety of motor skills and fundamental movement patterns may reduce the chances for early specialising athletes to induce overuse injuries (32). This is important for young soccer players who are potentially susceptible to early specialisation (20).

While recent literature has acknowledged the importance of AMSC for youth athletes, there has been no previous research into the efficacy of an AMSC intervention with youth athletes (44). The overall aim of this study was to evaluate the efficacy of an AMSC intervention on physical bio-motor qualities of youth soccer players during the competitive season. It was hypothesized that there will be improvement in the bio-motor qualities of the youth soccer players at the end of the intervention period. A secondary aim of this study was to compare the differences in results between the U14 and the U15 squad. It was hypothesized that the U15 squad would show greater improvements in the bio-motor qualities due to maturation status in comparison to the U14 squad.

METHODS

Experimental Approach to the Problem

This quasi-experimental study was performed over 10 weeks during the soccer in-season. The 10-week period included a pre-testing week, an 8-week AMSC programme intervention, and a post-testing week. All participants recruited took part in the intervention. Participants were only included in the final analysis if they had completed both testing sessions and were free from injury. Players were asked to abstain from any strenuous physical activity before for the pre- and post-testing sessions. All players were familiarised with the testing and training protocols prior to taking part in the intervention.

Subjects

Thirty-four (n = 34) underage academy soccer players were recruited from a League of Ireland Soccer Academy club. Parental consent and participant assent was sought prior to the pre-testing session. Twenty-seven underage academy soccer players with a mean (± SD) age, stature, body mass, and maturity offset of 14.6 ± 0.47 years, 172.21 ± 6.33 cm, 61.19 ± 8.86 kg, and 0.8 ± 0.7 years respectively, completed both testing sessions and were included in the study (Table 1). The participants represented the club in the Under-14 (n = 13) and Under-15 (n = 14) age groups. Ethical approval was provided by the Research Ethics Committee of Atlantic Technological University, Galway and was conducted according to the Declaration of Helsinki for studies involving human subjects. The minimum sample size for this study was estimated using G*Power (28). A power analysis for a two-tailed paired-samples t-test indicated that the minimum sample size to yield a statistical power of at least .8 with an alpha of .05 and a medium effect size (*d* = 0.5) is 27.

Procedures

Anthropometric measurements of the participants were taken prior to the warm-up and in accordance with the International Society for the Advancement of Kinanthropometry (ISAK) guidelines (35). Standing and seated stature was measured to the nearest 0.01 metre, using a stadiometer (Seca model 213, Hamburg, Germany) and body mass was measured to the nearest 0.1 kg using a digital weighing scales (Seca model 875, Hamburg, Germany). Participants removed footwear, wore minimal clothing and stood in an anatomically neutral position with the head placed in the Frankfort plane during both measurements. Maturity Offset (Equation 1) was calculated using standing and seated stature of the participants (37).

A testing battery including a countermovement jump (CMJ), 20-metre sprints, and 3 repetition maximum (RM) chin ups was designed to be performed will all participants. The testing order was performed in the order mentioned above, as per the National Strength and Conditioning Association Testing Guidelines (23). The testing protocol followed standardised procedures from previous research (23,39,53). A standardised RAMP warm-up was performed prior to testing, which included jogging, dynamic movements, sprint mechanics drills, low-level plyometric drills, and a gradual progression towards maximal sprinting (27). The participants were familiar with the exercises in the testing

Table 1. Descriptive statistics for participants pre- and post-intervention (Mean ± SD).*

		Age (Years)	Standing Height (cm)	Body Mass (kg)	Maturity Offset (Years from PHV)
Overall	Pre	14.6 ± 0.47	172.21 ± 6.33	61.19 ± 8.86	0.8 ± 0.7
	Post	14.8 ± 0.48	172.67 ± 6.17	61.97 ± 8.90	1.0 ± 0.7
U14	Pre	14.2 ± 0.16	169.29 ± 6.6	56.85 ± 9.7	0.4 ± 0.6
	Post	14.39 ± 0.16	170 ± 6.52	57.65 ± 9.73	0.6 ± 0.6
U15	Pre	15.0 ± 0.32	174.92 ± 4.86	65.21 ± 5.76	1.3 ± 0.4
	Post	15.2 ± 0.32	175.14 ± 4.83	65.99 ± 5.91	1.5 ± 0.4

** PHV = peak height velocity*

protocol as they had previously performed them in their training.

The CMJ was performed with hands akimbo positioned on the hips. Players were instructed to stand with feet hip width apart, flex their knees and hips to a self-selected depth, and then jump as high as possible ensuring legs remained fully extended during the flight phase of the jump. Players performed three attempts, with 2 minutes rest allowed between trials and the highest jump was used for subsequent data analysis (53). The CMJ variables were measured using a Dual Force Plate System at a sampling frequency of 1000 Hz (Force Decks FDLite, Vald Performance, Newstead, Queensland, Australia). The device has previously been shown to be reliable (CV < 10%, ICC >0.70) (24).

Sprint speed was collected at 5-metres, 10-metres and 20-metres using electronic timing gates (SmartSpeed Pro, Fusion Sport, Coopers Plains, Australia). These timing gates have been found to be reliable in terms of CV% (<10%) and ICC (>0.70) values (10). Players performed 2-3 practice trials ranging from 70-90% of their perceived maximum effort and were allowed 3-5 minutes rest in between trials. Players were instructed to start 0.5 metres behind the first timing gate and to sprint maximally in their own time past the 20-metre timing gate. Times were recorded to the nearest 0.01 seconds with the quickest of the three times being used for subsequent data analysis (53).

The 3RM chin up was calculated as the participant's body mass in addition to the maximum load lifted for three repetitions (39). Beginning from a still hanging position, using an underhand grip, participants were instructed to concentrically flex the elbows and pull their chest to the bar before eccentrically lowering themselves to a fully extended position (39). The 3RM for the chin up test was determined based on either technical breakdown or a failure to lift a given weight for 3 reps, then the previous weight lifted was taken as the participant's 3RM (39). The 3RM weighted chin up is a reliable test in team sport athletes (22,39). A 1RM predicted formula was used to convert data from 3RM scores to predict an estimated 1RM (14). These scores were also divided by bodyweight to provide relative strength measures.

Following the pre-testing session described above, an 8-week AMSC training intervention was

Table 2. 8-week AMSC-based strength training intervention performed by the U14 squad (n=13).*

	Exercise	AMSC Component	Sets	Reps
Warm Up				
	Skipping Rope		1	3-5 mins
	Bear Crawl (Fwd/Bwd/Lat)		2	5m each
	Broom Mobility		1	5 each
	Crab Reach		1	5 each
	BW Lunge Series		1	8 each
	BW Squat Jump		1	5
Power				
	Box Jump with Altitude Land	*Jumping, Landing and Rebounding Mechanics*	1	6
	SL Lateral Box Jump		1	3 each
Strength				
A1	Goblet Squat	*LB Bilateral*	3	8
B1	Inverted Row	*UB Pulling (Horizontal)*	3	8
C1	Plank	*AR/C/B*	3	25 s
D1	DB Hinge / RDL	*LB Bilateral*	3	8
E1	Push Up	*UB Pushing (Horizontal)*	3	5
F1	Side Plank	*AR/C/B*	3	15 sec each
G1	Split Squat	*LB Unilateral*	3	5 each

** Fwd = forwards; Bwd = backwards; Lat = lateral; BW = bodyweight; SL = single leg; AR/C/B = Anti-rotation, core, and bracing; DB = dumbbell; RDL = Romanian deadlift; LB = lower-body; UB = upper-body*

Table 3. 8-week AMSC-based strength training intervention performed by the U15 squad (n=14)*

	Exercise	AMSC Component	Sets	Reps
Session 1				
Warm Up				
	Skipping Rope		1	3-5 mins
	DL Glute Bridge		1	5
	SL Glute Bridge		1	5 each
	90/90 Hip Rotations		1	5 each
	World's Greatest Stretch		1	5 each
	Eccentric Push Up		1	6
	Split Squat		1	5 each
	SL Romanian Deadlift		1	5 each
	OH Squat		1	10
	Pogo Hops		2	15
Power				
	Lateral Bound & Rebound	*Jumping, Landing and Rebounding Mechanics*	2	5 each
	Long Jump		2	5
Strength				
A1	BB Back Squat	*LB Bilateral*	3	5
A2	DB Bench Row	*UB Pulling (Horizontal)*	3	8
A3	Pallof Press	*AR/C/B*	3	12 each
B1	DB Romanian Deadlift	*LB Bilateral*	3	5
B2	SA KB Shoulder Press	*UB Pushing (Vertical)*	3	5 each
B3	Deadbug	*AR/C/B*	3	8 each
Session 2				
Warm Up				
	Skipping Rope		1	3-5 mins
	DL Glute Bridge		1	5
	SL Glute Bridge		1	5 each
	90/90 Hip Rotations		1	5 each
	World's Greatest Stretch		1	5 each
	Eccentric Push Up		1	6
	Split Squat		1	5 each
	SL Romanian Deadlift		1	5 each
	OH Squat		1	10
	Pogo Hops		2	15
Power				
	Altitude Landings	*Jumping, Landing and Rebounding Mechanics*	2	5
	DB Squat Jump		2	6
Strength				
A1	BB Back Squat	*LB Bilateral*	3	5
A2	DB Bench Press	*UB Pushing (Horizontal)*	3	8
A3	Plank	*AR/C/B*	3	30 s
B1	DB Romanian Deadlift	*LB Bilateral*	3	5
B2	Chin Ups	*UB Pulling (Vertical)*	3	5
B3	Side Plank	*AR/C/B*	3	20 s each

** DL = double leg; SL = single leg; ea = each; OH = overhead; DB = dumbbell; BB = barbell; AR/C/B = Anti-rotation, core, and bracing; SA = single arm; KB = kettlebell; LB = lower-body; UB = upper-body* implemented (Tables 2 and 3). This AMSC training programme intervention was developed based on the recommendations from previous research in this area (14,50). The intervention aimed to include all the components and movements as per the AMSC model (38). The training intervention was integrated within the squads normal training schedule, which included 1 gym session a week for the U14 squad (Table 2) and 2 gym sessions a week for the U15 squad (Table 3). Highlighting the difference in training frequency between age groups is important, as it impacts results. This frequency difference arose from each squad's training schedule, constrained by time and availability. Following the 8-week intervention the testing battery performed during pre-testing was performed again and comparisons were be made between results from both testing sessions to determine the effectiveness of the training intervention.

Statistical Analyses

The statistical analysis software that was used to analyse the data was IBM SPSS statistical analysis programme version 28 (IBM Corporation, New York, NY, USA). Data was presented as mean ± SD. The Shapiro-Wilk test was be used for checking the normality. Where the data was found to be parametric, a paired samples t-test was used to analyse pre-and post-test scores. The Wilcoxon signed rank test was used to compare the means of non-parametric variables. Comparisons of group characteristics and baseline scores was undertaken using Analysis of Variance (ANOVA) for variance across the means and effect size (Cohen's D) was included to demonstrate practical significance (5). Effect sizes (ES) of < 0.2, 0.2, 0.5, and >0.8 were denoted as trivial, small, moderate, and large, respectively (11). Additionally, the smallest worthwhile change (SWC) was used to determine the individual responsiveness to training, calculated as 0.2 of the between-subject SD for the total sample, using preintervention data (26). Statistical significance was set at $P \leq 0.05$. The SWC was expressed as a percentage of the group mean and a frequency count was then used to determine the number of individuals who made changes greater than the SWC, with this being used to identify individuals who made a "positive response" in performance.

RESULTS

Pre- and post-testing scores for the U14 and U15 age groups can be found in Tables 4 and 5 respectively. The U14s showed significant improvements in CMJ peak power (Figure 1), chin up 3RM and chin up

Table 4. Testing scores for the U14 (n = 13).*

	Pre	Post	Sig	ES	Inference
Speed					
5m (s)	1.07 ± 0.05	1.07 ± 0.05	.759	0.02	Trivial
10m (s)	1.85 ± 0.06	1.86 ± 0.06	.481	0.17	Trivial
20m (s)	3.23 ± 0.1	3.24 ± 0.11	.679	0.10	Trivial
Jumping Ability					
JH (cm)	28.76 ± 4.33	29.67 ± 3.5	.058	0.23	Small
PP (N)	2408.46 ± 560.68	2543.62 ± 522.92††	.006	0.25	Small
EccDur (ms)	570.23 ± 70.87	528.54 ± 70.58	.172	0.59	Moderate
RSI_{mod} (m/s)	0.33 ± 0.05	0.36 ± 0.07	.098	0.66	Moderate
MPF (N)	968 ± 179.99	987.54 ± 188.72	.209	0.11	Trivial
PI (N)	377.85 ± 105.9	394.38 ± 111.77	.449	0.15	Trivial
TTTO (ms)	904.46 ± 104.35	876.69 ± 110.5	.453	0.26	Small
Strength					
Ex. Load (kg)	3.33 ± 4.09	4.44 ± 5.61	.205	0.23	Small
3RM (kg)	60.17 ± 11.79	62.1 ± 12.9††	.004	0.16	Trivial
Est. 1RM (kg)	66.13 ± 12.96	68.24 ± 14.17††	.004	0.15	Trivial
Relative 1RM	1.16 ± 0.07	1.18 ± 0.09	.171	0.25	Small

** JH = jump height; PP = peak power; EccDur = eccentric duration; RSI_{mod} = reactive strength index modified; MPF = mean propulsive force; PI = propulsive impulse; TTTO = time to take-off; RM = repetition maximum*
†Significantly different from pretest (p < 0.01)
††Significantly different from pretest (p ≤ 0.05)

Table 5. Testing scores for the U15 age group (n = 14).*

	Pre	Post	Sig	ES	Inference
Speed					
5m (s)	1.1 ± 0.06	1.07 ± 0.07††	.020	0.17	Trivial
10m (s)	1.84 ± 0.08	1.82 ± 0.1	.183	0.22	Small
20m (s)	3.16 ± 0.15	3.13 ± 0.16	.062	0.19	Trivial
Jumping Ability					
JH (cm)	32.96 ± 4.64	34.91 ± 4.93†	< .001	0.41	Small
PP (N)	3214.5 ± 478.1	3368.79 ± 478.15††	.012	0.32	Small
EccDur (ms)	603.86 ± 130.29	594.71 ± 121.04	.502	0.07	Trivial
RSI_{mod} (m/s)	0.39 ± 0.09	0.41 ± 0.08	.083	0.23	Small
MPF (N)	1223.36 ± 183.28	1218.57 ± 177.75	.837	0.03	Trivial
PI (N)	447.31 ± 50.9	478.26 ± 56.3††	.001	0.58	Moderate
TTTO (ms)	900.21 ± 178.5	911.21 ± 181.26	.517	0.06	Trivial
Strength					
Ex. Load (kg)	9.09 ± 6.26	8.75 ± 6.59	.666	0.05	Trivial
3RM (kg)	74.3 ± 7.56	74.74 ± 7.44	.652	0.06	Trivial
Est. 1RM (kg)	81.66 ± 8.31	82.14 ± 8.18	.652	0.06	Trivial
Relative 1RM	1.25 ± 0.11	1.25 ± 0.11	.706	0.06	Trivial

** JH = jump height; PP = peak power; EccDur = eccentric duration; RSI_{mod} = reactive strength index modified; MPF = mean propulsive force; PI = propulsive impulse; TTTO = time to take-off; RM = repetition maximum*
†Significantly different from pretest (p < 0.01)
††Significantly different from pretest (p ≤ 0.05)

Table 6. Percentage changes in sprint speed, jump performance and strength for both age groups. Presented as mean ± SD.*

	U14			U15		
	Performance Change (%)	SWC	n > SWC	Performance Change (%)	SWC	n > SWC
Sprint Speed						
5m	-0.41 ± 3.68	-0.01	4	-2.95 ± 4.16 ††	-0.01	10
10m	-0.59 ± 2.72	-0.01	3	-1.12 ± 3.00	-0.02	9
20m	-0.32 ± 2.57	-0.02	3	-1.08 ± 1.99	-0.03	6
Jumping Ability						
JH	3.71 ± 5.95	0.87	6	5.99 ± 4.09	0.93	12
PP	6.19 ± 6.91	112.14	7	5.08 ± 6.08	95.62	11
EccDur	5.94 ± 16.93	-14.17	7	0.94 ± 9.50	-26.06	6
RSI_{mod}	8.06 ± 16.26	0.01	5	7.70 ± 12.58	0.02	7
MPF	2.00 ± 5.28	36.00	5	-0.13 ± 6.89	36.66	4
PI	6.44 ± 16.75	21.18	6	7.06 ± 6.70	10.18	9
TTTO	2.27 ± 13.39	-20.87	6	-1.51 ± 7.93	-35.70	3
Strength						
Est. 1RM	3.12 ± 4.21	2.59	2	0.71 ± 4.57	1.66	6
Rel. 1RM	1.64 ± 4.08	0.01	5	-0.49 ± 3.59	0.02	5

** JH = jump height; PP = peak power; EccDur = eccentric duration; RSI_{mod} = reactive strength index modified; MPF = mean propulsive force; PI = propulsive impulse; TTTO = time to take-off; RM = repetition maximum*
†Significantly different from U14 (p < 0.01)
††Significantly different from U14 (p ≤ 0.05)

predicted 1RM post-intervention ($p < 0.05$). Effect sizes for these variables ranged from trivial to small (ES = 0.15 to 0.25). All other scores showed no significant differences pre- to post-intervention ($p > 0.05$). The U15s showed statistically significant improvements in 5m sprint time, CMJ height, CMJ peak power, and CMJ propulsive impulse ($p < 0.05$). Effect sizes for these variables ranged from trivial to moderate (Range: ES = 0.17 to 0.58). All other scores showed no significant differences pre- to post-intervention ($p > 0.05$).

Performance changes, represented as a percentage, are shown in Table 6. The U14 squad showed an increase in mean performance changes for jumping, strength and sprint variables. The U15 squad showed an increase in mean performance changes for all variables except MPF, TTTO and Relative 1RM. The U15 squad showed a significant improvement in 5m sprint time compared to the U14 squad. There were no significant differences between age groups for any other variables. While there were no significant differences between the groups for many variables, the number of participants that showed an increase greater than the smallest worthwhile change (SWC) was high for many variables. For all jumping variables, between five and seven U14 players showed increases greater than the SWC. Similar findings were recorded among the U15 squad, while they also showed large individual increases in 5m and 10m sprint times. Individual percentage changes for 5m sprint time are presented in Figures 2 and 3.

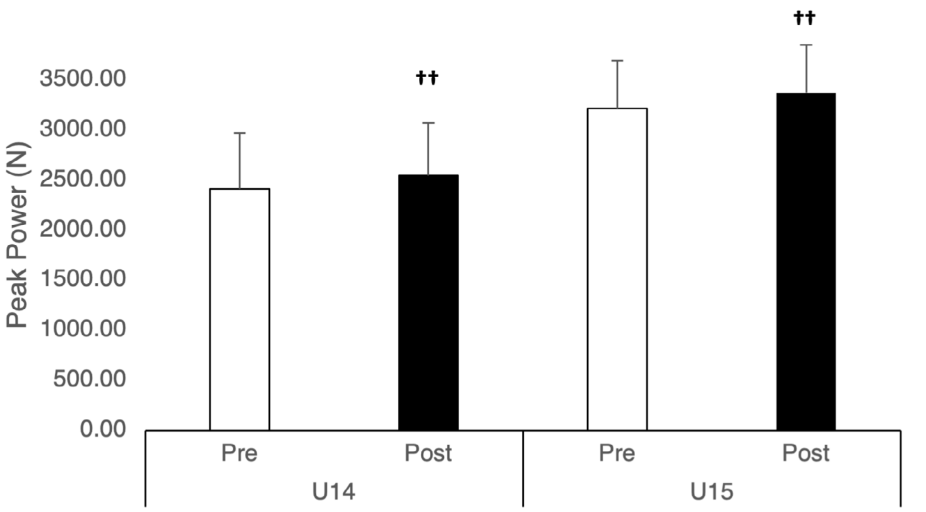

Figure 1. Differences in mean scores for CMJ Peak Power.
†† significant at p < 0.05.

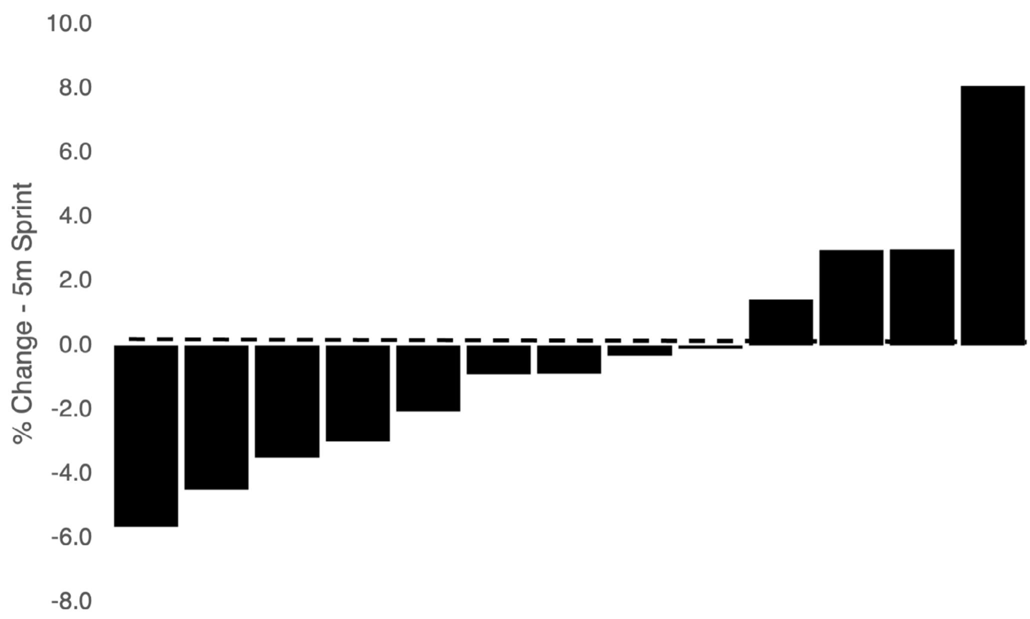

Figure 2. Individual percentage changes in 5m sprint performance post-intervention for the U14 squad. Horizontal line represents the SWC for the group (0.74%).

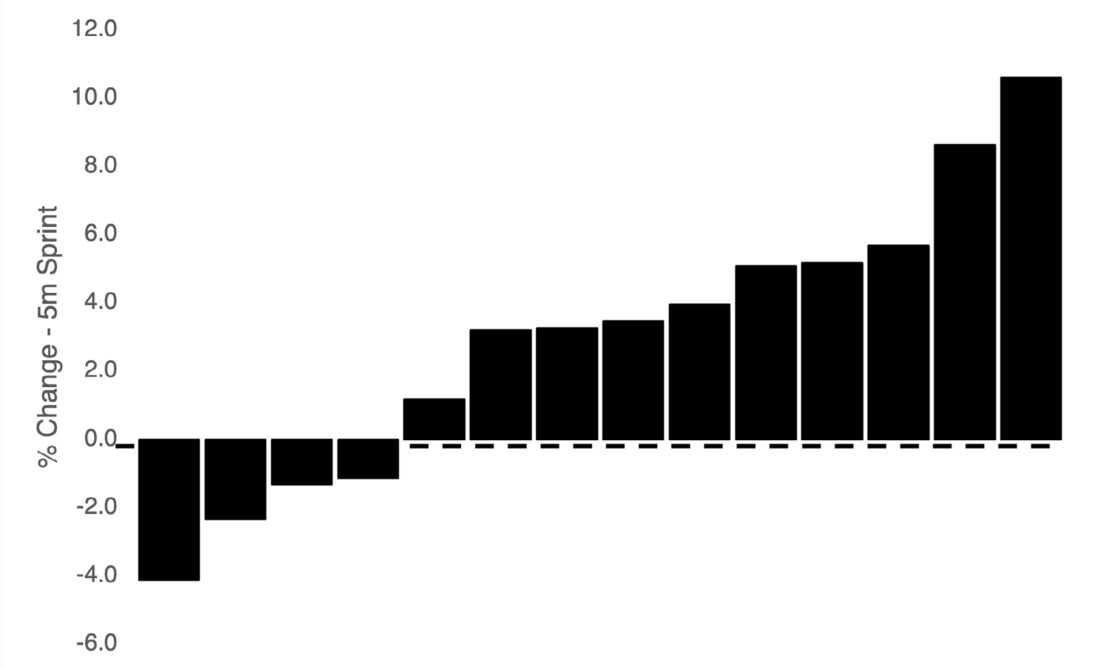

Figure 3. Individual percentage changes in 5m sprint performance post-intervention for the U15 squad. Horizontal line represents the SWC for the group (0.83%).

DISCUSSION

The aim of this study was to evaluate the efficacy of an AMSC programme on physical bio-motor qualities of youth soccer players during the competitive season. There were significant improvements in some physical bio-motor qualities for youth soccer players after an 8-week in-season intervention. It was observed that the U14 squad significantly increased PP during the CMJ ($p < 0.01$, ES = 0.58) and both the 3RM ($p < 0.05$, ES = 0.16) and the estimated 1RM for the chin up exercise ($p < 0.05$, ES = 0.16). The U15 squad significantly decreased their 5m sprint time ($p < 0.05$, ES = 0.16), while significantly increasing their JH ($p < 0.01$, ES = 0.41), PP ($p < 0.05$, ES = 0.32), and PI ($p < 0.05$, ES = 0.58) during the CMJ test. There were no significant changes across other variables for either age group. There was a significant difference between age groups for 5m sprint time. Furthermore, 38% of the U14 squad experienced positive changes exceeding the SWC across all 7 jump variables. Similarly, 43% of the U15 squad experienced positive changes greater than the SWC for sprint speed, strength, and 5 of the jump variables; JH, PP, EccDur, RSI_{mod}, and PI. These results demonstrate that it is possible to induce improvements and maintain speed, power, and strength qualities of youth soccer players during the competitive season. Similar results were found in elite youth football players which demonstrated that 6 weeks of strength training reduced injury incidence, injury burden and improved physical qualities such as jump ability, change of direction, sprinting, isometric strength ($p < 0.001$, ES = 3.02 to -7.23) (15). Improvements in speed, strength, and jumping performance in high-level youth soccer players are in-line with previous research by Oliver et al. (47). Improvements seen in metrics such as JH, PP, and PI correspond to physical capacities that can benefit soccer performance, including speed, strength, and change-of-direction ability (8). Changes in these metrics suggest that players may have improved their physical capacities after the 8-week intervention. Increases in PP also suggests that individuals can produce a higher rate of doing work during the same movement post-intervention (8). This could have potential transfer to on pitch performance by allowing players to produce greater PP which may potentially lead to quicker sprint and change of direction times and abilities (12,47). Previous literature has found correlations between speed and power metrics and soccer performance, 30m sprint times (r = 0.744), CMJ ability (r = -0.769), and squat jump ability (r = -0.712) all showed strong correlations to zigzag agility without the ball (p = 0.01) (30). A recent meta-analysis has established that advancing maturation status was associated with faster sprints and greater jump height in youth athletes (2). Furthermore, maintaining these qualities throughout the competitive season suggests that physical performance on the field can also be maintained through the implementation of effective strength training (56,59,60). This allows players to maintain physical outputs throughout the entire season, ensuring consistent performance and potential reduction of injury burden (15). Previous research reported that no decrements in performance metrics were observed among U14 soccer players after 12 weeks of preseason strength and power training (60). This supports the findings from the current study that implementing an AMSC based training programme throughout the season can benefit the physical attributes of youth soccer players.

While there were not many significant results regarding the group means, there were some noteworthy practical results. The U14 squad recorded a moderate ES for both EccDur and RSI_{mod} variables, suggesting that some practical changes were made over the intervention period. Furthermore, the U14 squad reported a small ES for JH and TTTO suggesting that improvements were also made. Similarly, the U15 squad reported a small ES for RSI_{mod}. These effect sizes suggest that there is still some practical significance to the results and that individuals can improve these jumping metrics during the competitive season (5, 21). These variables may have small and moderate effect sizes but not be statistically significant due to the small sample size in this study. Variables such as RSI_{mod}, TTTO, and EccDur can be used to detect for neuromuscular fatigue, however, improvements in such metrics can also indicate positive adaptation to training (8). Players that decreased their EccDur time post-intervention suggests that they may be able to reach the same or a greater jump height with a shorter eccentric muscle contraction time (8). Enhanced hormonal levels and increased muscle mass displayed by adolescents post-PHV may have aided such neurological adaptations (18,32). It has previously been suggested that the trainability of muscular strength is influenced by maturational status and is an important predictor of training outcomes (7). The ability to produce greater forces during the eccentric phase of a jump may result in greater muscle stiffness, increasing tendon lengthening, which allows more efficient elastic energy storage and utilisation due to shorter amortisation phases (25). This can be beneficial on the pitch for actions such as jumping, sprinting, and changing direction, where being able to produce greater forces in a shorter timeframe is advantageous to athletic performance (30,55). Decreases in TTTO also suggest that players can reach similar jump heights in shorter overall contraction times, while RSI_{mod} refers to the ratio of the jump height to the time spent to produce the output (8). It has been theorized that muscular-tendon unit adaptations during growth and maturation such as increases in cross sectional area, fascicle length, pennation angles, tendon stiffness, pre-activation and motor-unit recruitment can all elicit improvements in stretch-shortening cycle ability (51). These findings are noteworthy because it provides practical information to coaches regarding the effectiveness of the training programme.

Another notable finding from this study is that several players showed an increase greater than the SWC for some metrics, including those that did not show significant improvements. This suggests that some players responded better to the training programme than others and further highlights the individual nature of adaptation to training (9). This reinforces the importance of monitoring training and individualising where possible to elicit the greatest adaptation for each player. From the U15 squad, CMJ JH and PP in 12 and 11 players respectively experienced improvements greater than the SWC post-intervention. Similarly, while there were no significant changes for 20m sprint time, three U14 players and six U15 players had improvements greater than the SWC, further highlighting the individual nature of adaptation (7). Furthermore, it has been suggested that the efficacy of sprint training becomes more apparent with increasing maturational status in boys with moderate effects occurring mid PHV and larger effects occurring post PHV (42). This adaptation has been hypothesized to occur due to the increase in muscular size, limb length, augmented neural development and motor coordination in boys during growth and maturation (42). It has also been proposed that growth related factors such as increase in stride length, improved stride frequency and shorter ground contact times are influential in sprinting velocity around PHV (42). It has also been hypothesized that peak weight velocity (occurs at the same time as PHV) could enable the accumulation of greater mass to contribute to force production during initial acceleration and sprint performance (29).

Some variables showed minimal change post-intervention, likely due to the intervention occurring during a busy period of the competitive season. It is likely that residual fatigue was accumulated as the congested period of the season progressed. Soccer match output impairs physical performance until at least 72 hours post-match and recovery time is individual between players (54). Furthermore, CMJ height varies in response to match output for elite youth soccer players (17). This suggests that fatigue may have been a factor that affected the magnitude of change in the speed, power, and strength variables. However, the U15 squad increased their mean CMJ JH by approximately 2cm across this period suggesting that improvements in physical performance are possible. During the 8-week intervention period, both squads played a match every weekend as well as partaking in a 4-day soccer tournament abroad mid-way through the intervention. While there were no metrics recorded to quantify the outputs of these matches, given the high playing level and the nature of the sport, the matches may have induced some level of fatigue in the players (1,3). Furthermore, there are differences in the physical demands of players during match play which will in turn effect the individual recovery period (4). Considerations were taken during the testing protocols to minimise these fatigue effects, including providing 48 hours of recovery after matches prior to testing sessions and having the testing sessions during normal training times so as not to add any additional workload for the players. As per the individual nature of recovery from match play, players may have experienced some level of residual fatigue during the testing sessions (4,54). It is also possible that some of the findings from this study were affected by the maturity status of the players. Most of the U14 players were circa-peak height velocity (PHV) during the intervention, while nearly all the U15 players were post-PHV during the intervention (Table 1). Strength adaptations from resistance training are greater in individuals who are circa- or post-PHV (18). It has been suggested that strength is trainable in boys and is sensitive to maturity status, possible adaptations include morphological, neurological and endocrinological (40). Similarly, for sprint speed adaptations, pre- and circa-PHV males make greater improvements from plyometric training, while post-PHV males make greater improvements from combined plyometric and strength training (33). Positive adaptations in strength could be related to faster sprint performance in youth athletes because of increased levels of testosterone, growth hormone and IGF-1 during the growth spurt (41). Furthermore, potential neural adaptations such as increased muscle activation rates, motor unit recruitment, decreased electromechanical delay, augmented stretch reflex could lead to enhanced bio-motor qualities during maturation especially in boys (36). These results might also indicate the elevated neural plasticity and increased sensitivity to motor control and coordination adaptation in childhood and pre-PHV, as opposed to the enhanced hormonal levels and increased muscle mass linked to adolescence and post-PHV (18). This may account for the U15 players showing slightly better improvements across the variables, particularly in sprint speed, compared to the U14 players. Further adaptations could have been due to the “synergistic adaptations” phenomena which is the interdependence between the specific adaptations of the imposed training modality and the related effects of growth and maturity (32).

This study is not without its limitations and are acknowledged. Due to the applied the nature of the research, it wasn’t possible to conduct the study using a control group in soccer academy, future research should endeavour to have a control group to allow for comparison of the training intervention. All players were part of an athlete development program and were required to receive strength and conditioning support. Another limitation of this study was the sample size that was included within one LOI football academy. Future research is needed to determine the efficacy of the program to across clubs and players. The academy playing philosophy and recruitment strategy could have also impacted the results. Additionally, it was not possible to eradicate the influence of other training stimuli throughout the intervention as the subjects were engaging in their regular soccer training. The study was conducted over a small in-season window, future research should look to replicate similar interventions across a longer training period. Future studies with greater sample sizes would increase the statistical strength of the research. Finally, there was a difference in training frequency between the two squads so comparing the results across age groups should also be made with caution. Future studies should aim to have the same training frequency between different age groups.

FUTURE APPLICATIONS

The findings from this study outline the importance of youth soccer players performing an AMSC programme during the competitive season. Implementing a training programme targeting the AMSC can be beneficial in developing and maintaining the speed, RFD, impulse and strength of youth male soccer players during the congested competitive season. This approach can help maintain physical qualities throughout the season, enabling for better physical performance on the pitch. By incorporating a well-designed AMSC programme, coaches can ensure that players not only sustain but also enhance their physical performance.

It is important to acknowledge factors such as fatigue and maturity status that may limit the improvements that can be made during the competitive season. Athletes going through PHV are still physically developing, and combined with effects of competition can lead to fatigue. However, careful planning and programming can minimise the negative effects of such factors and aid in the improvement of physical performance on the field. Future research should now focus on examining the effects of an AMSC-based intervention on other physical variables, such as lower body strength, rate of force development and impulse, to determine the effect of such a programme on other performance variables. Furthermore, future research should compare intervention outcomes across age groups to identify if certain ages see greater improvements in bio-motor qualities. This research supports the provision of strength training modalities during the competitive season in academy football. S&C practitioners need to be cognizant of the synergistic adaptations that occur due to growth and maturation in this cohort.

CONFLICTS OF INTEREST

There are no conflicting relationships or activities.

FUNDING

This study received no specific funding in order to be completed.

ETHICAL APPROVAL

Ethical approval was provided by the Research Ethics Committee of Atlantic Technological University, Galway and was conducted according to the Declaration of Helsinki for studies involving human subjects

DATES OF REFERENCE

Submission - 14/11/2024
Acceptance - 23/06/2025
Publication - 12/09/2025

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