MCQUILLIAM, S.J., CLARK, D.R. ERSKINE, R.M. and BROWNLEE, T.E. 2023. Physical testing and strength and conditioning practices differ between coaches working in academy and first team soccer. *International journal of sports science and coaching* [online], 18(4), pages 1045-1055. Available from: https://doi.org/10.1177/17479541231155108

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2023

International Journal of
Sports Science
& Coaching

Original research

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International Journal of Sports Science
& Coaching
2023, Vol. 18(4) 1045–1055

DOI: 10.1177/17479541231155108
journals.sagepub.com/home/spo
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Abstract

Scientific guidelines exist regarding strength and conditioning (S&C) best practice, for both first team and academy level soccer. However, it is not known if these research-informed guidelines are followed in such applied settings. The aim of this study was to investigate current S&C practice in first team and academy level (men's and women's) soccer, in multiple countries/continents. A total of 170 participants, who were involved with the delivery of S&C support at their soccer club, completed a comprehensive survey, describing their training methods. Data were analysed using Pearson's chi-square test of independence and independent t-tests. Statistical significance was set to $p < 0.05$. A greater proportion of academy compared to first team coaches assessed acceleration/sprint (92% *vs.* 83%, $p=0.026$), jump (95% *vs.* 83%, $p=0.023$) and change of direction performance (77% *vs.* 61%, $p=0.031$). The weekly training structure differed between groups, particularly within women's squads, with women's academy coaches reporting the lowest session frequency of all groups (1.59 ± 0.62 session per week, 44 ± 17 min duration). A greater proportion of academy (54%) *versus* first team (35%) coaches prioritised bodyweight training ($p=0.031$), despite a similar distribution of movement patterns trained. Overall, 44% S&C coaches reported using training intensities below strength training guidelines (≥80% 1RM). To conclude, there were many differences in S&C practice between S&C coaches working with first team and academy squads but particularly noteworthy was the greater proportion of academy coaches prioritising bodyweight training compared to first team coaches, which may limit physical development in academy players.

Keywords

Association football, bodyweight training, fitness, long-term athlete development, periodization, resistance training

Introduction

Soccer is a dynamic, high-intensity sport, where a player's strength, power and speed are important contributors to match performance.[1,2] Notably, maximum strength correlates with acceleration, sprint and jump performance in both first team[3] and youth soccer players.[4] Additionally, increased strength may benefit sport-specific skills, such as winning tackles and headers.[1] Beyond single instances within matches, professional soccer teams with greater lower-limb strength and power attain higher league finishing positions than their weaker competitors.[5] Furthermore, higher strength levels may reduce match-induced muscle damage[6] and injury risk in soccer.[7] As such, there is an abundance of research examining training methods to improve a soccer player's strength capacity.

The current guidelines of strength and conditioning (S&C) suggest best practice in team sports, such as soccer, at both first team and academy levels.[8,9] However, this may not be representative of the programming S&C coaches actually implement with their athletes. In first team players, a narrative review by Turner and Stewart[8] suggested a twice-weekly programme in-season, maintaining loads of 70–90% single repetition maximum (1RM), in

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order to maintain strength, alongside a variety of power modalities, e.g., weightlifting and plyometric training. However, there may be perceived obstacles to the implementation of resistance training (RT) in soccer. For example, the frequency of RT sessions in the English Premier League and Championship has been reported to be less than recommended by Turner and Stewart[8] for first team players.[10] Beyond this, it is likely there are additional contrasts between research-based recommendations and actual applied practice in first team squads. This could be due to limited resources, such as training facilities, staffing, time available to perform RT[11] and concerns over RT-induced muscle soreness influencing subsequent training/match performance.[12]

In recent years, there has been an increase in research investigating RT in youth sport,[13–15] particularly in soccer. Meylan et al.[9] created a model to develop muscular power in youth soccer players at various stages of biological maturity, following a similar structure to the long-term athlete development (LTAD) model proposed by Côté.[16] Initially focusing on fundamental movements (5–12 years old) and concluding with a focus on maximal strength training (16+ years old),[9] this model is progressive by design, with each stage building upon the last and laying the foundation for the next. This highlights the importance of long-term planning to optimise strength and power development in the maturing soccer player. However, similar to first team players, there are contrasts between these recommendations for academy players and actual reported practice. Meylan et al.[9] recommended 2–3 weekly sessions from 15 years of age onward. In contrast, it has been reported that an elite soccer academy does not undertake regular RT sessions until reaching the under 16 age group,[17] which is less than recommended. Soccer governing bodies have released their own LTAD structures, such as the Elite Player Performance Plan (EPPP) in England.[18] However, these guidelines are generic and open to interpretation by the practitioner. For example, the guidance for strength and power development consists of a ‘preliminary S&C programme’ and ‘speed, strength, power’.[18] Although vague language is not necessarily negative, it allows for a wide variety of methods to be implemented, potentially explaining some of the differences in player development between academies.[19]

Up-to-date knowledge of the current landscape would aid transition of research into the applied environment, thus improving S&C practice and research going forward. Despite match success in both first team and academy settings being positively influenced by powerful actions,[1,2] it would be inappropriate to use the same S&C training approaches to develop these actions in both populations. This is due to the differences in the primary focus and characteristics of the specific population the S&C coaches are working with. However, elements of training would need to align between academy and first team squads to ensure players are prepared to transition from academy to first team training demands. Consequently, the primary aim of this study was to compare current S&C practice in soccer between first team and academy settings. To maximise ecological validity, these initial first team *vs.* academy analyses incorporated all participants (S&C coaches), regardless of whether they worked with men’s or women’s squads, and regardless of which country they worked in. However, we have recently shown that S&C practice varied between global regions,[20] while practice also differed between coaches working with men’s *vs.* women’s squads.[21] Thus, we followed up our initial analyses with first team *vs.* academy comparisons in specific countries, and then specifically in men’s/women’s squads to elucidate whether first team *vs.* academy differences existed in specific settings. It was hypothesised that the methods used to develop strength and power as well as testing preferences would differ between academy and first team coaches due to the nature of LTAD- *vs.* performance-orientated training. It was also hypothesised that there would be disparity between RT guidelines from the scientific literature and current practice at both levels, which would be attributed to perceived time restrictions and concerns regarding high intensity loading during RT.

Methods

Survey design and data collection

This study was designed to provide comprehensive information about current practices of S&C coaches in academy and first team soccer. The survey was entitled, “*Current Practice of Strength and Conditioning Coaches in Soccer”* and was similar in design to previous work.[22–24] This study aimed to recruit practitioners involved with the provision of S&C services with either first team or academy squads at soccer clubs worldwide. The online survey platform, ‘Jisc Online Surveys’ (formerly Bristol Online Survey) was used to create the questionnaire and collect answers anonymously. The survey was reviewed for content validity via initial discussions within the research team (which included S&C practitioners). Following this, the survey was pilot-tested by coaches directly involved with the delivery of S&C support (n = 3) and academics (n = 3), who have experience of applied soccer practice. Subsequently, there was a reduction in the number of questions, as well as rewording of others to increase practicality of the research tool, which was approved by the research team. The questionnaire was then translated from English into French, Spanish, German, Italian and Portuguese to increase the global accessibility to practitioners in soccer. This was done by colleagues and associates of the research team, who were native speakers of the respective languages. The online questionnaire took 17±7 min to complete and comprised six sections aiming to elucidate current programming of S&C implemented in soccer. This included the S&C coach’s background and their practice regarding physical testing, strength and power development, plyometric training, speed development and periodisation. In line with previous survey-based research in soccer, the survey was distributed directly to potential participants via email and indirectly via sharing a website link on social media platforms, a method that has been used previously.[25] Participants were encouraged to share the link with their professional networks to increase distribution of the survey.[26] Responses were not limited to one per soccer club due to the potential for multiple squads within a single club. Due to using indirect data collection methods to distribute the survey, it was not possible to calculate response rate. Data were collected between 01 December 2019 and 01 July 2020.

Participants

To ensure responses were reflective of current S&C practice, to meet the inclusion criteria participants needed to be directly involved with the delivery of S&C support in soccer within a soccer team at the time of responding to the survey. Participants were fully informed of the potential risks and benefits of the investigation and acknowledged informed consent prior to starting the survey. A total of 177 participants completed the survey. If key data were missing, such as whether participants worked with men's or women's, first team or academy squads, these participants were excluded from the study (n = 7). These responses from the United Kingdom (UK, n = 70), European countries excluding the UK (EUR, n = 17), South America (SA, n = 69) and North America (NA, n = 14) were subsequently analysed, culminating with a final sample of n = 170. Respondents comprised S&C/fitness coaches (n = 115), sport scientists (n = 46) and technical coaches (n = 9). Participants were grouped into first team or academy staff (Table 1). The participants who worked within academy settings (n=78), worked with players with ages ranging from under nine to under 23 years-old, and 58% worked with two or more age groups. The study received ethical approval from the Liverpool John Moores University Research Ethics Committee (ethics code: 19/SPS/046).

Statistical analysis

For exercise prescription, a sub-selection of data was analysed. On account of the interaction between sets, repetitions and intensity, only answers that provided all three elements were included used for statistical analysis. When ranges were provided in a response, e.g., session duration 30–60 min, the mean of the two points was used for analysis. Due to the wide range and individual variations reported for exercise selection, the raw data were coded

Table 1. Participant demographic data.

Country	Squad	Job role	Years in S&C	Education (%)
United Kingdom	First Team n = 27	S&C/Fitness coaches = 74%	0–5 years = 48%	Bachelors: 3 (11%)
		Sport scientists = 26%	6–10 years = 33%	Masters: 17 (63%)
		Technical coaches = 0%	>10 years = 19%	PhD: 7 (26%)
	Academy n = 43	S&C/Fitness coaches = 58%	0–5 years = 61%	Bachelors: 30%
		Sport scientists = 37%	6–10 years = 30%	Masters: 56%
		Technical coaches = 5%	>10 years = 9%	PhD: 14%
Rest of Europe	First Team n = 4	S&C/Fitness coaches = 75%	0–5 years = 25%	Bachelors: 0%
		Sport scientists = 25%	6–10 years = 0%	Masters: 50%
		Technical coaches = 0%	>10 years = 75%	PhD: 50%
	Academy n = 13	S&C/Fitness coaches = 92%	0–5 years = 46%	Bachelors: 8%
		Sport scientists = 8%	6–10 years = 23%	Masters: 77%
		Technical coaches = 0%	>10 years =31%	PhD: 15%
South America	First Team n = 51	S&C/Fitness coaches = 72%	0–5 years = 33%	Bachelors: 27 (53%)
		Sport scientists = 18%	6–10 years = 31%	Masters: 10 (20%)
		Technical coaches = 10%	>10 years =35%	PhD: 4 (8%)
	Academy n = 18	S&C/Fitness coaches = 67%	0–5 years = 50%	Bachelors: 8 (44%)
		Sport scientists = 28%	6–10 years = 22%	Masters: 6 (33%)
		Technical coaches = 5%	>10 years = 28%	PhD: 1 (6%)
North America	First Team n = 10	S&C/Fitness coaches = 60%	0–5 years = 30%	Bachelors: 0%
		Sport scientists = 40%	6–10 years = 40%	Masters: 80%
		Technical coaches = 0%	>10 years =30%	PhD: 20%
	Academy n = 4	S&C/Fitness coaches = 0%	0–5 years = 50%	Bachelors: 50%
		Sport scientists = 75%	6–10 years = 50%	Masters: 50%
		Technical coaches = 25%	>10 years = 0%	PhD: 0%

* Difference between 1st team and academy within group comparison (p < 0.05).

into more general groups by movement pattern, to allow for a quantitative comparison of exercise prescription, e.g., back squat was categorised as a bi-lateral squatting pattern.

Raw survey data were initially exported into Microsoft Excel (*Excel 2019, Microsoft, Washington, USA*) to reorganise, prior to being imported into SPSS (*version 26, IBM, Armonk, USA*) for statistical analysis. To assess between group (i.e., academy *vs.* first team) differences for nominal and ordinal data, frequency analysis was performed via Pearson's chi-squared test of independence, with results reported as percentages of the group. Further, Cramer's V effect size was provided for each chi-square model. To assess between-group differences for ratio data, independent samples T-tests were used including Cohen's d effect size. Statistical significance was set to $p < 0.05$.

Results

Demographics

There were no differences between first team and academy S&C coaches regarding their academic education, overall (χ^2 (3, $N = 170$) = 5.13, $p = 0.162$, Cramer's $V = 0.174$), or within each geographic groups (Table 1). Overall, there was a greater proportion of academy coaches having 0–5 years' experience in S&C than first team coaches (59% *vs.* 37% respectively) and a relatively more first team coaches having >10 years' experience than academy coaches (32% *vs.* 17% respectively; χ^2 (2, $N = 170$) = 8.89, $p = 0.012$, Cramer's $V = 0.229$). There was also a greater proportion of men's academy coaches having 0–5 years' experience in S&C than first team men's coaches (53% *vs.* 33% respectively) and a relatively more first team coaches having >10 years' experience than academy coaches (32% vs. 17% respectively; χ^2 (2, $N = 170$) = 9.60, $p = 0.008$, Cramer's $V = 0.298$). There were no differences within each geographic group. Overall there were no differences in the distribution of job roles between first team and academy respondents (S&C coaches = 72% *vs*. 63% respectively, sport scientists = 23% *vs*. 32% respectively, technical coaches = 5% *vs*. 5% respectively; χ^2 (2, N = 170) = 1.83, $p = 0.400$, Cramer's $V = 0.104$) or within geographic or gender groups.

Physical testing

Overall relatively fewer first team coaches reported testing change of direction ability (COD) than the academy coaches (χ^2 (1, $N = 170$) = 6.61, $p = 0.010$, Cramer's $V = 0.197$; Figure 1), with no differences in 1RM testing (χ^2 (1, $N = 170$) = 0.41, $p = 0.521$, Cramer's $V = 0.049$; Figure 1), external power (χ^2 (1, $N = 170$) = 0.003, $p = 0.955$, Cramer's $V = 0.004$; Figure 1), jump testing (χ^2 (1, $N = 170$) = 1.52, $p = 0.218$, Cramer's $V = 0.095$; Figure 1), sprint performance (χ^2 (1, $N = 170$) = 2.01, $p = 0.156$, Cramer's $V = 0.109$; Figure 1), muscular endurance (χ^2 (1, $N = 170$) = 2.17, $p = 0.141$, Cramer's $V = 0.113$; Figure 1), anaerobic capacity (χ^2 (1, $N = 170$) = 1.69, $p = 0.193$, Cramer's $V = 0.100$; Figure 1) or aerobic capacity (χ^2 (1, $N = 170$) = 1.83, $p = 0.176$, Cramer's $V = 0.104$; Figure 1).

Relatively more UK first team coaches reported testing muscular endurance than their academy counterparts (48% *vs.* 14% respectively; χ^2 (1, $N = 70$) = 9.81, p = 0.002, Cramer's $V = 0.387$). A greater proportion of SA academy coaches than SA first team coaches reported testing power with external load (61% *vs.* 39% respectively; χ^2 (1, $N = 69$) = 4.03, $p = 0.045$, Cramer's $V = 0.211$) and COD (83% *vs.* 55% respectively; χ^2 (1, $N = 69$) = 4.585,

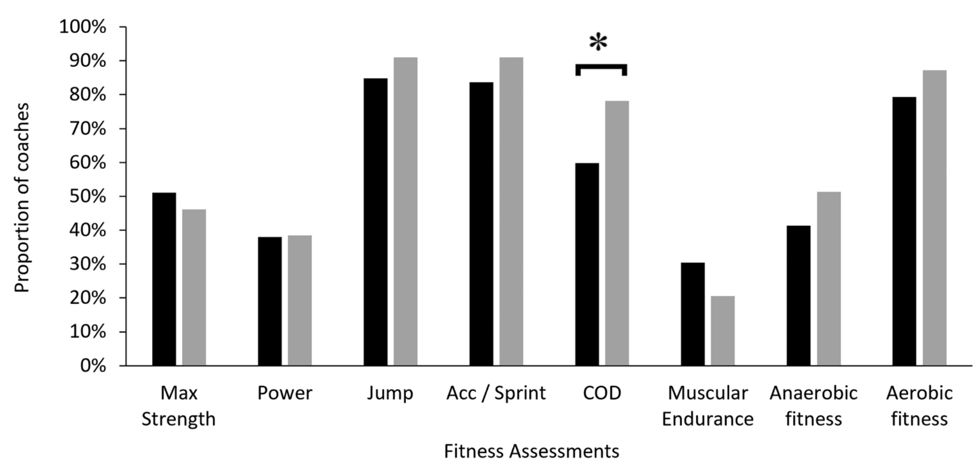

Figure 1. The proportions of first team (black bars) and academy (grey bars) coaches, who use each physical performance test in their practice with their soccer players. *Difference between first team and academy (p < 0.05).

$p = 0.032$, Cramer's $V = 0.352$). In men's squads relatively more academy than first team coaches reported assessing sprint performance (95% *vs.* 81% respectively; χ^2 (1, N = 108) = 5.11, p = 0.024, Cramer's V = 0.217) and COD (82% *vs.* 56% respectively; χ^2 (1, N = 108) = 8.26, p = 0.004, Cramer's V = 0.277). No other differences were seen within geographic or gender groups.

Collectively there was a similar proportion of first team than academy coaches conducting testing at the start of pre-season (83% *vs.* 91% respectively; χ^2 (1, N = 170) = 2.56, p = 0.11, Cramer's V = 0.029) and end of pre-season (57% *vs.* 51% respectively; χ^2 (1, N = 170) = 0.47, p = 0.49, Cramer's V = 0.130). There were differences in the proportion of coaches conducting fitness testing during the season in first team compared to academy squads (71% *vs.* 85% respectively; χ^2 (1, N = 170) = 4.66, p = 0.03, Cramer's V = 0.165) and at the end of a season (42% *vs.* 58% respectively; χ^2 (1, N = 170) = 3.95, p = 0.047, Cramer's V = 0.153). Relatively fewer men's first team S&C coaches conducted fitness testing than academy coaches in-season (67% *vs.* 85%; respectively χ^2 (1, N = 108) = 5.04, p = 0.025, Cramer's V = 0.216) and end of season testing (33% *vs.* 55% respectively; χ^2 (1, N = 108) = 5.05, p = 0.025, Cramer's V = 0.216).

Training prescription

There was a greater proportion of academy coaches, who prioritised bodyweight training than first team squad coaches (56% *vs.* 22% respectively; χ^2 (1, N = 147) = 17.59, p < 0.001, Cramer's V = 0.346). Furthermore, a post-hoc power calculation revealed that this χ^2 analysis had a power of 0.99, thus demonstrating sufficient statistical power. This was consistent in both men's (academy = 52% *vs.* first team = 21%; χ^2 (1, N = 93) = 9.37, p = 0.002, Cramer's V = 0.317) and women's (academy = 69% *vs.* first team = 24%; χ^2 (1, N = 54) = 9.81, p = 0.002, Cramer's V = 0.426) comparisons but there were no differences within each geographic group.

Overall, there was a greater proportion of first team S&C coaches who priorities free-weight RT (first team = 65% *vs.* academy = 41%; χ^2 (1, N = 147) = 8.15, p = 0.004, Cramer's V = 0.235). This was consistent in both men's (first team = 67% *vs.* academy = 44%; χ^2 (1, N = 93) = 4.50, p = 0.034, Cramer's V = 0.220) and women's (first team = 63% *vs.* academy = 31%; χ^2 (1, N = 54) = 4.61, p = 0.032, Cramer's V = 0.292) comparisons but there were no differences within each geographic group.

Overall, there were no differences between the proportion of first team and academy coaches programming bi-lateral squats (χ^2 (1, N = 156) = 0.51, p = 0.474, Cramer's V = 0.057; Figure 2), bi-lateral hinges (χ^2 (1, N = 154) = 0.77, p = 0.381, Cramer's V = 0.070; Figure 2), weightlifting movements and derivatives (WL; χ^2 (1, N = 156) = 0.26, p = 0.609, Cramer's V = 0.041; Figure 2), unilateral exercises (χ^2 (1, N = 156) = 1.98, p = 0.159, Cramer's V = 0.113; Figure 2) or plyometrics (χ^2 (1, N = 156) = 0.54, p = 0.462, Cramer's V = 0.059; Figure 2). Sub-group analysis showed a greater proportion of women's first team S&C coaches utilised WL more so that women's academy S&C coaches (35% *vs.* 6% respectively; χ^2 (1, N = 57) = 5.22, p = 0.022, Cramer's V = 0.303).

When the aim was to train strength in season, there was no difference between first team and academy groups for the number of sets (t_{45} = 1.64., p = 0.109, Cramer's V =; Figure 3A) or repetitions (t_{45} = −1.46., p = 0.153, Cramer's V =; Figure 3B). First team S&C coaches prescribed a greater RT intensity when converted to a percentage of 1RM than academy S&C coaches (t_{45} = 2.35., p = 0.002, Cramer's V =; Figure 3C).

When comparing the methods used to prescribe exercise intensity, there were no differences between first team and

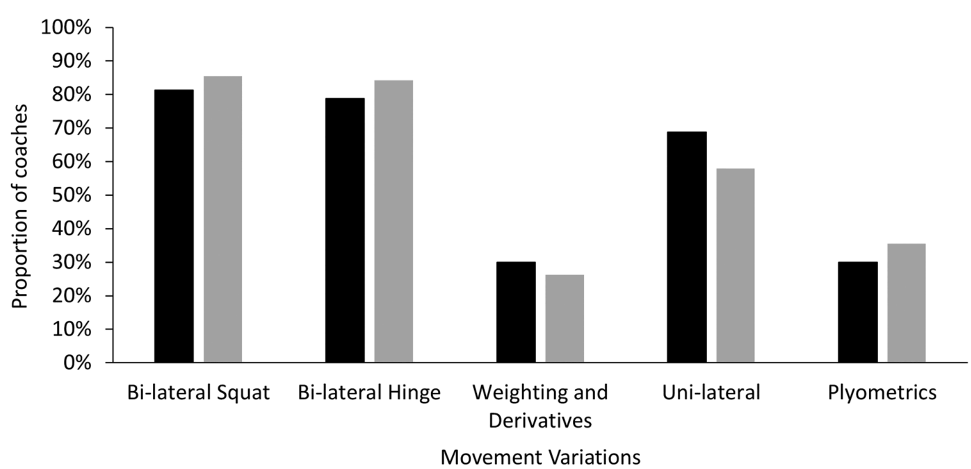

Figure 2. The proportions of first team (black bars) and academy (grey bars) coaches, who incorporate these movement patterns/exercise types into their practice to develop strength and/or power with their soccer players.

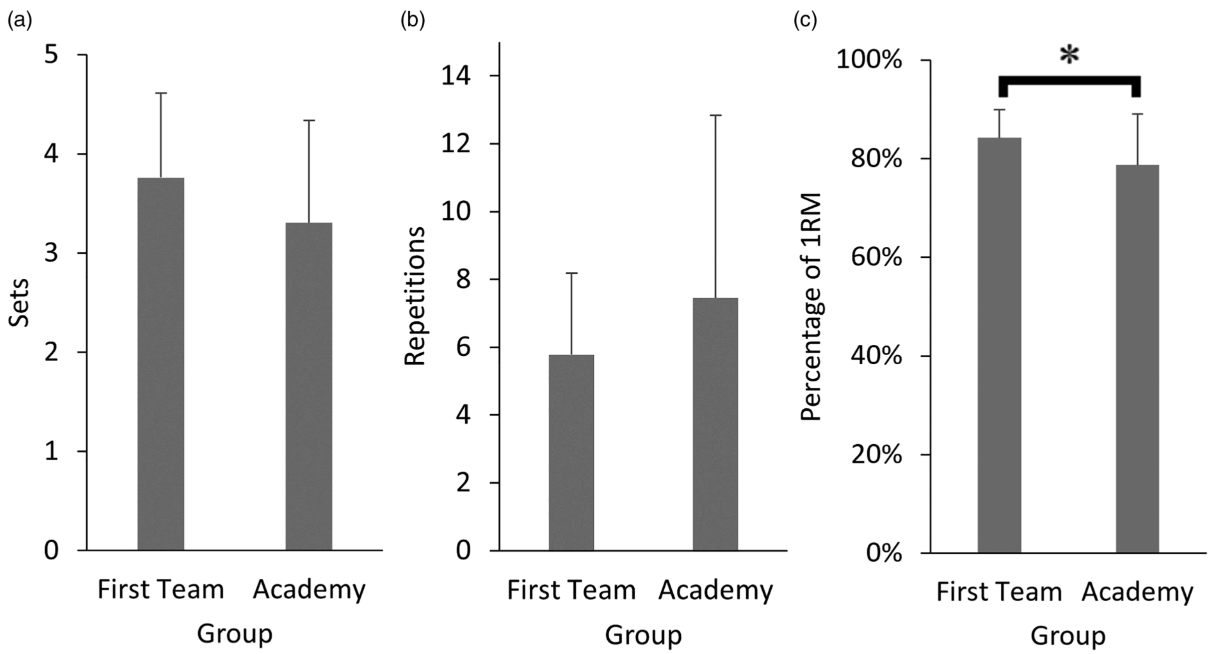

Figure 3. The sets (A), repetitions (B) and training intensity (C) first team and academy coaches prescribe to for strength training in-season. *Difference between first team and academy (p < 0.05).

academy coaches for %1RM (41% *vs.* 40 respectively; χ^2 (1, $N = 170$) = 0.02, $p = 0.904$, Cramer's $V = 0.009$), subjectively selected by the coach (44% *vs.* 53% respectively; χ^2 (1, $N = 170$) = 1.40, $p = 0.237$, Cramer's $V = 0.091$) or subjectively selected by the athlete (44% *vs.* 56% respectively; χ^2 (1, $N = 170$) = 2.82, $p = 0.09$, Cramer's V = 0.129). Overall, a greater proportion of first team S&C coaches utilised velocity measures to prescribe RT load than academy S&C coaches (33% *vs.* 19% respectively; χ^2 (1, $N = 170$) = 3.88, $p = 0.049$, Cramer's $V = 0.151$). At a sub-group level, a greater proportion of SA academy coaches utilised percentage 1RM (69% *vs.* 31% respectively; χ^2 (1, $N = 69$) = 4.94, $p = 0.03$, Cramer's V = 0.268) than SA first team squads.

Periodisation

Pre-season. First team squad coaches reported more weekly S&C sessions than academy coaches overall (3 ± 1 *vs.* 2 ± 1, $t_{163} = 3.74$, $p < 0.001$, $d = 0.5$), in the UK ($t_{64} = 2.12$, $p = 0.04$, $d = 0.5$); Table 2), men's group ($t_{104} = 2.36$, $p = 0.020$, $d = 0.5$; Table 2), women's group ($t_{57} = 2.56$, $p = 0.013$, $d = 0.7$; Table 2), with no difference in the SA group ($t_{66} = 1.10$, $p = 0.28$, $d = 0.3$; Table 2).

Overall, there was a difference in session duration between first team and academy S&C coaches during pre-season (53 ± 17 min *vs.* 48 ± 18 min; $t_{162} = 1.99$, $p = 0.926$, $d = 0.3$). Women's first team S&C coaches reported a greater pre-season session duration than women's academy S&C coaches ($t_{58} = 2.22$; $p = 0.030$, $d = 0.6$; Table 2). There were no differences within other groups.

In-season. There was no difference between first team and academy groups overall for in-season weekly S&C sessions (2.17 ± 0.92 *vs.* 2.10 ± 0.87; $t_{164} = 0.46$, $p = 0.644$, $d = 0.1$) or within geographical groups. Women's first team coaches reporting a greater number of sessions than academy coaches ($t_{59} = 2.32$, $p = 0.024$, $d = 0.7$; Table 2). There was no difference in the average S&C session duration between first team and academy groups overall (48 ± 18 min *vs.* 46 ± 17 min, $t_{161} = 0.49$, $p = 0.488$, $d = 0.1$) or within geographical or gender groups (Table 2).

Restrictions

Relatively more first team coaches were concerned with potential muscle soreness following an S&C session than academy coaches overall (χ^2 (1, $N = 170$) = 17.74, p < 0.001, Cramer's $V = 0.323$; Figure 4), UK (74% *vs.* 37%, χ^2 (1, $N = 72$) = 10.02, $p = 0.002$, Cramer's $V = 0.373$), SA (80% *vs.* 56%, χ^2 (1, $N = 46$) = 8.01, $p = 0.005$, Cramer's $V = 0.417$), men's squads (65% *vs.* 35%, χ^2 (1, $N = 108$) = 9.35, $p = 0.002$, Cramer's $V = 0.294$) and women's squads (77% *vs.* 50%, χ^2 (1, $N = 62$) = 4.47, $p = 0.034$, Cramer's $V = 0.269$). There were no differences in the percentage of first team and academy coaches, who felt their S&C practice was restricted by time (χ^2 (1, N = 170) = 0.01, $p = 0.980$, Cramer's $V = 0.002$; Figure 4) or facilities/equipment (χ^2 (1, $N = 170$) = 0.83, $p = 0.363$,

Table 2. Time spent in formal S&C sessions, frequency – sessions per week.

	Pre-season		In-season	
Squad	Frequency	Duration (min)	Frequency	Duration (min)
UK first team	2.80 ± 0.96 *	45 ± 9	2.12 ± 0.65	45 ± 12
UK Academy	2.37 ± 0.70 *	47 ± 14	2.02 ± 0.78	46 ± 15
SA first team	3.10 ± 1.11	58 ± 19	2.32 ± 1.04	51 ± 20
SA Academy	2.78 ± 0.94	49 ± 22	2.33 ± 0.69	47 ± 16
Men's first team	2.85 ± 1.10 *	48 ± 18	2.13 ± 0.81	58 ± 15 *
Men's Academy	2.42 ± 0.79 *	48 ± 19	2.25 ± 0.88	48 ± 16 *
Women's first team	3.07 ± 1.00 *	58 ± 15 *	2.20 ± 1.02 *	53 ± 16
Women's Academy	2.31 ± 1.01 *	48 ± 16 *	1.59 ± 0.62 *	44 ± 17

* Difference between 1st team and academy (p < 0.05).

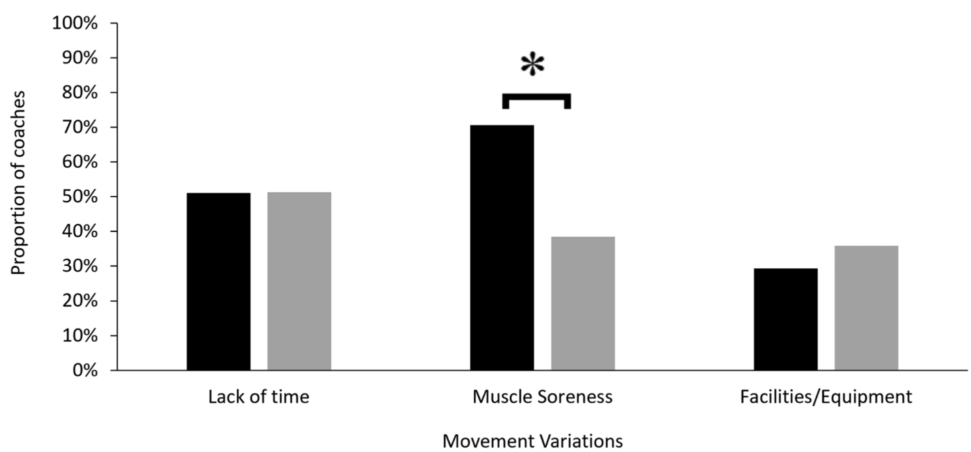

Figure 4. The proportions of first team (black bars) and academy (grey bars) coaches, who perceived their S&C practice to be restricted by lack of time, potential muscle soreness following training and facilities/equipment. *Different to academy coaches (p < 0.05).

Cramer's $V = 0.070$; Figure 4). This was consistent within each geographic and gender group.

Discussion

The present study sought to conduct a comprehensive survey of S&C provision in soccer, specifically comparing the practices of first team and academy coaches, in both men's and women's soccer, all on a global scale. A total of 170 coaches took part, making this the largest number of individual respondents exploring S&C practice in a single sport. The findings presented here support the original hypothesis that there would be differences between academy and first team S&C coaching practice. The main findings are i) a greater proportion of academy coaches prioritised bodyweight training compared to first team coaches despite a similar distribution of movement patterns such as bi-lateral squatting. ii) There was no different in prescribed strength training sets and repetitions between first team and academy coaches but training intensity, as a percentage of 1RM, was greater by first team S&C coaches. iii) A greater proportion of academy S&C coaches reported testing more frequently throughout the season than first team coaches. The strength training approach and testing preferences differed between academy and first team S&C coaches, which was likely due to the nature of LTAD- *vs*. performance-orientated training.

When considering that soccer is dominated by aerobic metabolism[27] and key moments can be defined by powerful actions,[2] it is not surprising that sprint and jump performance, and aerobic fitness were the most assessed physical attributes by both first team and academy S&C coaches. However, our study showed that a greater proportion of academy S&C coaches COD performance compared to first team coaches (Figure 1). The assessment of COD commonly involves acceleration(s), deacceleration(s) and a variety of change of direction options. These components are critical to goal scoring situations in professional soccer[28] and may explain why a larger percentage of academy S&C coaches implement them (Figure 1). The greater proportion of academy coaches conducting COD as well as power, speed and aerobic fitness tests could be due to the concept of long-term athlete development and talent identification,[29] which is the predominant focus of soccer academies. This finding was supported by the increased regularity of testing by academy compared to first team S&C coaches. While coaches with first team and academy squads followed a consistent pattern of physical testing at the start and the end of pre-season, relatively more academy than first team coaches conducted testing during the season and at the end of the season. The physical development of academy soccer players can be non-linear and, consequently, regular testing can highlight the sporadic fluctuations apparent in physical performance and enable contextualisation (e.g., comparing with simultaneous measures of biological maturation) to further aid player development.[30]

Other invasion games that are influenced by lower-body strength and power have had current S&C practice surveyed to help gain a better understanding of the training methods applied.[22–24,31] A greater proportion of academy coaches in this study prioritised bodyweight training compared to first team squad coaches (56% *vs*. 22%, respectively), although there appears to be a similar pattern between first team and academy coaches regarding exercise selection. This appears to be considerably different to the previously referenced studies, where over 90% of S&C coaches working with first team[23,31] and youth athletes[22] have reported utilising the squat in other sports, in comparison to 81% of first team and 86% of academy coaches here. This may be explained by the proportion of coaches using unilateral alternatives (Figure 2). Unilateral RT is perceived to transfer better to sport-specific actions, such sprinting and change of direction.[32] However, both bilateral and unilateral training produced similar improvements in jump and sprint performance when training volume and intensity are matched. This suggests these factors are more important than the exercise itself.[32–34]

Like the squat, over 90% of S&C coaches working with both professional[23,24,31] and youth[22] athletes in other sports have previously reported using weightlifting movements. However, the proportions of first team and academy S&C coaches utilising weightlifting movements were much lower here (30% and 26% respectively) than the 67% of S&C coaches in professional soccer recently reported by Weldon et al.[35] It is difficult to determine why there is such a difference in the proportion of coaches using weightlifting derivatives, as both studies asked S&C coaches for the top five exercise in their programs. However, the demographics included within this study are much broader, which may account for some of the variation. This may explain the higher frequency of bi-lateral hinge movements in both groups in the current study (Figure 2). Movements such as these target the gluteal and hamstring musculature, both of which contribute heavily during running, while the latter is also a common injury site in soccer.[36,37] While traditional RT of the posterior chain can be an important part of a soccer S&C programme, the omittance of weightlifting by 72% of coaches overall and 93% of women's academy S&C coaches is a unique finding and future research should explore why fewer S&C coaches in soccer programme weightlifting exercises than coaches in other sports, such as rugby union and basketball.[23,31]

The ability to maintain or even build strength throughout a season may be important to powerful sporting actions as well as increasing players' match availability.[4,7] In our study, the number of sets and repetitions prescribed for strength training did not differ between first team and academy coaches, however there was in training intensity (Figure 3). Research does suggest a focus on technique and lower training intensities with less experienced youth athletes to develop training competency[15] and may explain the difference in training intensity seen here. While the means in strength training prescription align with those suggested for first team[8] and youth soccer players,[9] the large range of repetitions (1 to 30) and exercise intensity (60 to 95% 1RM) highlight the variability between coaches' practice. This indicates that a large proportion of coaches deviate from development models in the scientific literature, which may have important long-term implications on physical performance, as adaptations to strength training are significantly lower when using training intensities <80%1RM.[38] Data from this study suggest that the reason S&C practice in soccer tends to deviate from scientific guidelines is due to limited time and perceived fear of players experiencing muscle soreness, which may then influence performance/recovery. We have recently shown that the majority of S&C coaches working in soccer tend to prescribe moderate intensity resistance training,[20] again, probably related to a fear of causing muscle soreness. However, until recently, there was no direct comparison between high- and moderate-intensity strength training specifically in soccer to indicate whether high-intensity strength training had any beneficial effects on performance in soccer players. We have recently shown that high-intensity (90% 1RM) strength training performed just once a week in-season had more performance benefits compared to moderate intensity (80% 1RM) strength training and soccer training only, with no difference in perceived muscle soreness.[39] Thus, it appears as though soccer players would indeed benefit from undertaking high-intensity strength training as part of their weekly training, as recommended in the scientific guidelines.[38]

It is commonly accepted that training intensity is a crucial factor when the aim is to increase an individual's strength.[40] There was a wide variety of methods used to prescribe RT load in first team and academy programmes, which may in part explain why there was little difference overall. Relatively more men's coaches than women's coaches used objective methods of training load prescription, such as measures of velocity (33% vs. 18% respectively). Due to instant feedback, velocity thresholds for different strength qualities and the ability to factor in daily fluctuations in strength and power this method has become increasing popular.[41] However, its adaptation appears limited within soccer with only 27% of participants using it to prescribe training intensity. This may be due to the financial cost of accurate units and the feasibility to implement this emerging technology within a training programme.[42] The limited contact time with academy athletes may also restrict the opportunity to assess strength. This assumption is supported by both session frequency and duration being lower in UK women's academy squads than their first team counterparts in this study, and potentially highlights the early stages of development within the women's game.[43]

The manipulation of training variables is an important aspect for improving performance. Previously, it has been reported that one to two S&C sessions per week take place in-season in first team[10] and academy soccer squads,[17] with guidelines suggesting two to three sessions per week are required for optimal performance/adaptation.[8,9] Weekly training structure differed between first team and academy within groups, particularly during preseason. During this time, first team coaches reported more S&C sessions than academy coaches (Table 2). This is likely reflective of the greater training demands of a full-time professional soccer programme. In contrast, there was no difference between first team and academy S&C session frequency in-season. On a sub-group level, however, S&C coaches of women's first team squads reported a greater number of sessions than their academy counterparts (Table 2), with women's academy squads having the lowest average of all groups. Despite the tremendous growth of female soccer in recent years, this is likely attributable to the ongoing development of women's soccer.[44] This lower exposure to S&C should be explored further, as young female players may be underpreparing for sporting demands which may increase the difficulty of progressing to first team soccer. This is especially pertinent given the high incidence of injury reported for this group.[45]

Multiple factors can influence an S&C programme, including but not limited to a congested fixture schedule, which can result in the accumulation of fatigue and limited opportunities to train, particularly in an elite professional team.[46] The most common factors restricting the incorporation of RT into S&C sessions for first team coaches were concerns over muscle soreness (71%) followed by lack of time (51%), while academy coaches were more commonly restricted by lack of time (51%; Figure 4). These findings were amplified in the UK. Muscle soreness and fatigue can be caused by different stimuli and managing the interplay of these is a key aspect to the implementation of RT alongside a technical sport-specific training programme. The large number of repetitions used by first team and academy coaches could potentially be causing greater muscle soreness and fatigue (Figure 3 and Figure 4), whereas high-intensity RT is associated with lower volume and, in turn, faster recovery.[47] Furthermore, time restrictions have previously been cited as a major factor when looking to implement injury prevention strategies in soccer,[11] with 32% of coaches in our study stating that limited time restricted their practice. A low-volume, high-intensity strength training protocol (90% 1RM) has previously been implemented in-season with professional[48] and academy soccer players,[39] and may be a potential solution to alleviating these perceived restrictions. Strength development needs to be effectively implemented alongside training other physical components important to soccer performance. Future research should investigate whether high-intensity, low-volume strength training has a meaningful impact in the applied setting, thus improving strength where time is perceived to be a limiting factor.

A limitation of the current study was that the survey only asked for training methods during a single match week. Successful soccer teams may play two or three matches per week for extended periods of time during the season, and this may influence the training methods implemented, potentially reducing the implementation of strength training further. This could mean that weekly S&C sessions may have been over reported here in teams at the highest level. However, standardising responses to a single match week allowed for a clearer comparison of the methods used by S&C coaches. Finally, when examining the answers provided for the prescription of sets, repetitions, and intensity, only 26% of the total responses could be used ($n = 41$). While the information provided by participants was rich with information, due to the wide variety of methods, it was not possible to convert all the information into traditional sets, repetitions, and percentage of 1RM that are universally recognised. As such, the RT prescription may deviate from our results. This key finding suggests that methods of assigning RT load according to the established scientific principles and research in soccer is a priority area for development. Future research should expand upon the findings presented here using qualitative research methods such as semi-structured interviews to investigate the context behind the findings. Finally, these findings cannot be extrapolated on a world-wide scale and should be considered within the context of the global regions included in this study.

Conclusion

This study compares S&C practices of coaches working with both first team and academy soccer players in Europe and North and South America, in both men's and women's soccer. Overall, a greater proportion of academy coaches prioritised bodyweight training compared to first team coaches (despite a similar distribution of movement patterns trained), which may limit physical development in academy players.

Practical applications

The aim of this study was to investigate current S&C practice in first team and academy level (men's and women's) soccer. This study highlights key differences between the S&C practices of coaches working with first team and academy soccer players. The limited inclusion of free-weight RT within academy settings may hinder the long-term physical development of youth players. The difference between S&C coaches working with women's academy and women's first team squads suggests that young female soccer players may be inadequately prepared to enter a first team environment. Further, coaches may use the information presented here as a reference point to compare and inform their own practice.

Acknowledgements

The authors would like to thank those who participated in the study.

Data availability

The authors confirm that the data supporting the findings of this study are available within the article.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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