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ABSTRACT: This study describes the contemporary practices of strength and conditioning coaches in professional soccer. Fifty-two strength and conditioning coaches from professional leagues across 18 countries completed an online survey, consisting of 45 questions, with eight sections: (a) background information, (b) muscular strength and power development, (c) speed development, (d) plyometrics, (e) flexibility development, (f) physical testing, (g) technology use, and (h) programing. A frequency analysis was used to assess and report responses to fixed response questions, and thematic-analysis used for open-ended questions to create clear, identifiable and distinct themes. All strength and conditioning coaches were educated to degree level or higher, 65% held strength and conditioning certifications and 54% held soccer coaching certifications. Concentric (100%) and eccentric (98%) modes of resistance were the most commonly prescribed, whereas the squat (including variations) (52%) was deemed the most important exercise for soccer players. Hang clean (33%) and multiple hops/lunges (89%) were the most programed Olympic weightlifting and plyometric exercises. Global Positioning Systems (94%) were the most utilized technology-based equipment. Time, scheduling and fixtures were the biggest issues faced, which made it difficult to periodize training programs and apply appropriate training loads. Furthermore, strength and conditioning coaches would like to further integrate technology to comprehensively monitor and test players, while also believing that technology will continue to be developed and integrated in the future. Strength and conditioning coaches from professional soccer can use the information from this study to review current practices and also provide ideas for diversifying or modifying future practices.

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INTRODUCTION

Strength and conditioning coaches (SCCs) in professional soccer should use their understanding of sports science and coaching to achieve the primary objectives of reducing injuries and improving physical and sports performance [1, 2]. Some SCCs specifically focus on physical training, monitoring and testing, whereas others have soccer coaching certifications and experience, allowing the development of technical, tactical, and mental skills [1, 3]. Nevertheless, SCCs should use strength and conditioning guidelines and research informed methods to develop physical capacities associated with superior soccer performance [1, 2, 3]. For example, small-sided games, repeated sprint ability (RSA) and repeated change-of-direction drills can improve aerobic and anaerobic capacities, while resistance training and plyometrics can improve strength, agility and power [1].

However, SCCs should also consider players individual differences (i.e., physical abilities, age, injury history, and morphological characteristics) and different physical demands across playing positions (i.e., distance covered, high speed running, and physical contacts) [1, 4, 5, 6]. Such information can then be used to design and implement a periodized training plan [7]. Each training plan should modify training volume and intensity, and prescribe appropriate recovery throughout preparatory and competition phases to optimize players' performance, reduce the accumulation of fatigue, and decrease injuries [3, 7]. However, this is difficult given the concurrent

physical demands of soccer and congested fixture schedules [8, 9]. Therefore, monitoring individual player's internal and external loads in physical training, soccer-specific training, and competitive matches, is commonly employed [9, 10]. This provides insight to each player's current condition, enabling SCCs to make informed decisions regarding periodized plans and strength and conditioning programs [9, 10].

Although literature advises the practical and scientific practices of SCCs in professional soccer, there is limited evidence addressing whether this translates well to field settings or if alternative methods are preferred [11]. Therefore, with the roles, responsibilities and practices of SCCs continuing to evolve, it is important contemporary practices are understood. This includes: data analytics [10, 12], supporting and monitoring player's psychological wellbeing [13], and injury reduction strategies [14].

Several studies have investigated the practices of SCCs in different professional sports, including: American football [15], ice hockey [16], baseball [17], basketball [18], rugby union [19], and swimming [20], but not soccer, which is surprising given its global popularity. Therefore, this study aimed to investigate the contemporary practices of SCCs working in professional soccer. This will help identify potential gaps between methods used, proposed guidelines, and real practice, facilitating the development of research and education resources tailored to the current climate. Furthermore, to provide a source of information for existing and progressing SCCs in soccer.

MATERIALS AND METHODS

Experimental Approach to the Problem

This cross-sectional, explorative study was designed to provide descriptive information about the contemporary practices of SCCs in professional soccer from different countries and leagues. Strength and conditioning coaches were required to describe their practices and opinions, to provide an understanding of their knowledge and practical application of sports science and coaching in professional soccer. The survey was adapted from previous research [11, 15, 19, 21] and developed using Google Forms. The survey consisted of eight sections: (a) background information, (b) muscular strength and power development, (c) speed development, (d) plyometrics, (e) flexibility, (f) physical testing, (g) technology use, and (h) programing. The survey included 35 fixed responses and 10 open-ended questions, and coaches could provide specific answers using "other" option for most questions (see Appendix 1). Some questions allowed more than one response, meaning some questions had more responses than others. Pilot testing was conducted by all members of the research team, then by three accredited SCCs, for a total three rounds of pilot testing before the survey was finalized. Pilot testing led to modifications to the wording and structure of the survey to avoid ambiguity of terms with varying definitions, and ensuring validity for use with this population. The study was conducted in accordance with the ethical standards of the Helsinki Declaration and approved by the Research Ethics Committee of the Technological and Higher Education Institute of Hong Kong.

Participants

To target and invite the relevant population for this study, an online search was conducted through available biographies (e.g., LinkedIn, professional club webpages) of SCCs working in professional soccer. Strength and conditioning coaches were sought from 28 countries with the most registered recreational and professional players according to the FIFA Big Count Statistical Summary Report [22]. Contact information and responses were received from SCCs in 14 of these countries. Furthermore, invited SCCs were requested to share the survey with their SCC network in professional soccer. This led to additional responses from professional soccer leagues in: Australia, Singapore, Slovakia and Thailand. Therefore, in total SCCs from 18 countries were included in this study. Due to unequal sample sizes from SCCs respective countries/continents of occupation, it was not feasible to draw direct comparisons within this study.

Procedures

All SCCs provided informed consent to initiate the anonymous online survey, and only fully completed surveys were used for analyses. The survey started with an explanation of the purpose, aims, required time-commitment, and confidentiality of information. Coaches were informed a copy of results may be sent to them upon request.

Statistical Analyses

All responses from Google Forms were downloaded into an Excel 2016 spreadsheet (Microsoft Corporation, Redmond, WA). Fixed response questions were assessed using a frequency analysis. Open-ended questions were assessed using a thematic analysis approach [23] using the following six-stage process: (a) familiarization with the data, (b) generating initial codes, (c) searching for themes, (d) reviewing themes, (e) defining and naming themes, and (f) producing the report. This thematic-analysis method has been used in prior studies surveying SCCs [11, 20]. Thereafter, overarching clear and identifiably distinct themes, representing the main ideas or patterns emerging from the raw data were generated for each open-ended question. Some responses provided sufficient information that more than one overarching theme could be identified. All themes were reviewed and agreed to by all authors.

RESULTS

Background Information

Fifty-two SCCs with a mean age of 35.6 ± 7.9 years and strength and conditioning experience of 11.5 ± 7.2 years, participated in this study. All SCCs worked in professional leagues across 18 countries, including: United Kingdom (38%), Belgium and Austria (each 10%), United States of America (6%), Portugal, Singapore, Italy, Slovakia and Spain (each 4%), and Argentina, Australia, Chile, France, Iran, Mexico, Netherlands, Sweden, and Thailand (each 2%). The most

reported leagues worked in were: English Championship (13%), English Premier League (10%), Belgian Jupiler Pro League (10%), Austrian Bundesliga (8%), United States of America – Major League Soccer (6%), and English League 2 (6%). This study had a larger sample compared to prior surveys in other professional sports (n = 20–43) [15–20], likely due to a broader inclusion criteria, instead of focusing on specific leagues or countries.

Strength and conditioning certifications were held by 65% of coaches, and 10% had more than one certification, including: United Kingdom Strength and Conditioning Association (UKSCA) Accredited Strength and Conditioning Coach (ASCC) (27%), National Strength and Conditioning Association (NSCA) Certified Strength and Conditioning Specialist (CSCS) (23%), and Australian Strength and Conditioning Association (ASCA) Strength and Conditioning Coach Accreditation (SCCA) (6%). All SCCs held degrees, and 96% were sports science orientated. The most reported degrees were: Master's degree (48%), Bachelor's degree (27%), and Doctorate of Philosophy (PhD) (25%). Soccer coaching certifications were held by 54% of coaches, including: Football Association Level 2 (15%), Union of European Football Associations (UEFA) A License (13%), UEFA B License (6%), and UEFA C License (4%). Strength and conditioning internships were completed by 64% of coaches, which were predominantly: before certification (44%), during certification (25%) and after certification (17%).

Muscular Strength and Power Development

Off-Season: The reported number of strength training sessions conducted each week were: three (62%), two (44%), four (27%), five (12%), one (8%), and six (4%). Whereas, 31–45 min (54%), 46–60 min (37%), 61–75 min (17%), 16–30 min (17%), 76–90 min (10%), and 0–15 min (4%) were the reported session durations. The most used set ranges were: 3–4 (87%), 5–6 (25%), 1–2 (14%), and 7–8 (8%). The most reported repetition ranges used per set were: 7–9 (62%), 4–6 (54%), 10–12 (48%), 15+ (12%), and 13–15 (10%). Other responses included: "depending on the athlete/player".

In-Season: The reported number of strength training sessions conducted each week were: two (62%), three (40%), one (35%), four (15%), and five (4%). Whereas, 31–45 min (58%), 16–30 min (42%), 46–60 min (30%), 61–75 min (10%), and 0–15 min (4%) were the reported session durations. The most used set ranges were: 3–4 (90%), 1–2 (37%), 5–6 (15%), and 7–8 (14%). The most reported repetition ranges used per set were: 4–6 (94%), 7–9 (44%), 1–3 (21%), and 10–12 (19%). Other responses included: "depending on the player's level".

Periodization, Set Loads and Recovery: Periodization strategies were used by 98% of coaches to structure programs. Other responses included: "depends on the definition of periodization". The most common methods to determine set loads were: athlete dependent (52%), predicted repetition maximum (44%), velocity (40%), repetition maximum (29%), subjective guess (21%), ratings of perceived exertion (21%), trial and error (19%), other (12%), and train to failure (6%). Other responses included: "bodyweight", "power output", "flywheel eccentric training", "my choice", "previous session loading" and "reps in reserve". The recovery time prescribed by SCCs between physical training, sports training and competition is presented in Table 1.

Resistance Training: All SCCs used resistance training with the most common modes being: concentric (100%), eccentric (98%), isometric (69%), variable (e.g. bands and chains) (65%), isoinertial (e.g. flywheel) (39%), and machine (37%). Other responses included: "pneumatic resistance". Olympic weightlifting and associated derivative exercises were prescribed by 67% of coaches, with the most common exercises being: hang clean (33%), power clean (31%), jump shrugs (25%), hang snatch (23%), clean high pull (21%), clean (21%), power jerk (19%), power snatch (19%), snatch (19%), jerk (15%), snatch high pull (8%), and other (8%). Other responses included: "clean press", "relate movements to sport", "landmine jerks", and "other free-weight variations". The top five weightlifting exercises programed by SCCs were ranked in order of importance, responses are presented in Table 2.

TABLE 1. The duration of recovery time that strength and conditioning coaches (n = 52) prescribe between speed, strength and power development sessions with sports training and competition.

Question	On the Same Day	24hr	36hr	48hr	>48hr
Recovery time between speed development and sports training session	67%	21%	6%	4%	2%
Recovery time between strength / power development and sports training session	60%	17%	4%	17%	2%
Recovery time between speed development and competition	6%	10%	21%	38%	25%
Recovery time between strength / power development and competition	8%	2%	12%	38%	40%

TABLE 2. Strength and conditioning coaches ranking (in order) of the five most important weightlifting exercises in their program.

Order of Importance	Exercises	Percentage of Coaches (n = 52)
1	Squat and Variations	52%
	Deadlift and Variations	19%
	Clean and Derivatives	13%
	None	2%
	Other: Mobility, Depends on Athlete, Bodyweight, Depends on Session Goals, Total Body Power, Core, Eccentric Hamstring Exercise.	n/a
2	Deadlift and Variations	37%
	Squat and Variations	33%
	Clean and Derivatives, Hip Thrust, Nordic, Lunge.	4%
	Plyometrics, Snatch and Derivatives, Bench Press, Leg Curl, None.	2%
	Other: Depends on Athlete, Depends on Session Goals, Leg Curl, Hamstring/Posterior Chain.	n/a
3	Lunges	21%
	Deadlift and Variations	12%
	Copenhagen Hip Adductor, Hip Thrust, Clean and Derivatives.	8%
	Squat and Variations, Nordic.	6%
	Bench Press, Plyometrics, Snatch and Derivatives, Step Up.	4%
	Olympic Weightlifting, Pull Up, None.	2%
	Other: Depends on Athlete, Depends on Session Goals, Lower Body Knee/Hip Dominant Exercise, Upper Body, Coordination Tasks, Single Leg Knee/Hip Dominant Exercise.	n/a
4	Squat and Variations	19%
	Step Up, Bench Press and Variations, Clean and Derivatives.	8%
	Calf Raise	6%
	Copenhagen Hip Adductor, Deadlift and Variations, Lunge, Prone Row, Snatch and Derivatives, None, Nordic.	4%
	Hip Thrust, Lat Pulldown, Overhead Press, Reverse Nordic.	2%
	Other: Depends on Athlete, Depends on Session Goals, Upper Body Press Vertical / Horizontal, Single Leg Hamstring Knee/Hip Dominant Exercise, Single Joint Assistance Hamstring Work, Push, Upper Push, Isometric Hamstring Bridge, Mobility.	n/a
5	Squat and Variations	12%
	Hip Thrust and Variations	10%
	Lunge and Variations	8%
	Snatch and Derivatives, Calf Raise, None, Pull Up.	6%
	Step Up, Deadlift and Variations, Nordic, Prone Row, Bench Press.	4%
	Cable Chops, Copenhagen Hip Adductor, Hamstring Bridge, Pallof Press, Clean and Derivatives, Push Press	2%
	Other: Depends on Athlete, Depends on Session Goals, Varied Dumbbell Exercise, Upper Body Pull Horizontal / Vertical, Explosive, Adduction, Bilateral Knee/Quad Dominant Exercise, Pull, Glute Dominant Exercise, Upper Pull.	n/a

*Variations and Derivatives were added when multiple types of the same exercise were reported (e.g., Squat, Overhead Squat, Front Squat).

Speed Development

All SCCs prescribed speed development exercises, with the most common being: plyometrics (87%), maximum speed sprinting (83%), strength training (79%), sport specific movements (69%), resisted running (52%), form running (38%), speed endurance (33%), Olympic weightlifting (25%), interval training (23%), over-speed running (19%), circuit training (15%), and uphill/downhill running (15%).

Plyometrics

All SCCs used plyometric exercises, predominantly for: lower body power (87%), speed development (81%), injury reduction (79%), improve jumping ability (63%), total body training (8%), upper body power (2%), and other (2%). Other responses included: "eccentric and concentric work". Plyometric exercises were mainly prescribed as: complex training (52%), before weights (37%), on separate

days (33%), and after weights (27%). Plyometric exercises were implemented: all year round (71%), in-season only (25%), pre-season only (23%), at training camps (4%), and off-season only (2%). The most prescribed plyometric exercises were: multiple hops/jumps (89%), bounding (79%), box drills (79%), standing jumps (63%), depth jumps (56%), jumps in place (54%), upper body plyometrics (12%), and other (2%). Other responses included: "jumping over hurdles".

Flexibility Development

All SCCs used flexibility exercises, which were predominantly prescribed: before practice (79%), after practice, (58%), independently/athlete led (54%), after workout (40%), before workout (31%), during practice (10%), during workout (8%), and other (2%). Other responses included: "concurrent active mobility". The duration of flexibility sessions reported were: 6–10 min (67%), 11–15 min (46%), 0–5 min (33%), 16–20 min (25%), and 20+ min (10%). The frequency that SCCs prescribed different types of flexibility exercise is presented in Table 3.

Physical Testing

All SCCs physically tested players, which were predominantly conducted: during the pre-season (58%), all year round (46%), in-season (42%), at training camps (10%), and off-season (4%). Other responses included: "anthropometry each week/month", "depends on various factors", "in some cases after injury", and "winter-break". The most reported physical tests used were to assess: cardiovascular endurance (92%), body composition (87%), muscular strength (81%), speed (81%), anthropometry (63%), muscular power (62%), acceleration (56%), flexibility (48%), agility (40%), anaerobic capacity (31%), and muscular endurance (8%). Athlete-wellbeing was monitored by 90% of coaches, via mobile device questionnaires (69%), verbal questionnaires (31%), and written questionnaires (15%).

TABLE 3. Percentage of responses from strength and conditioning coaches (n = 52) for the frequency in which different methods of flexibility training are used.

Type of Stretch	Commonly	Sometimes	Never
Ballistic	25%	44%	31%
Dynamic	90%	6%	4%
Active	60%	38%	2%
Passive	8%	73%	19%
Static	25%	67%	8%
PNF	10%	58%	33%

Note: PNF - proprioceptive neuromuscular facilitation.

Technology Use

All SCCs used technology-based equipment, with global positioning systems (GPS) (94%), speed gates (73%), heart rate monitors (71%), electronic jump mats (50%), force plates (50%), mobile phone applications (40%), bar velocity trackers (35%), video analysis software (33%), body composition analyzers (31%), wearable technology (15%), and metabolic analysis devices (10%) being the most reported. Other responses included: "local positioning monitoring", "isometric and isokinetic dynamometry", and "isometric muscle testing".

Programing

Five open-ended questions were asked, allowing more detailed responses from SCCs, which were used to create higher order themes. The percentage of responses to each theme and exemplar responses are provided in Tables 4a-4e.

DISCUSSION

This is the first study to investigate the practices of SCCs in professional soccer across different countries and leagues. A key finding was the high level of professional and academic certifications possessed by SCCs compared to surveys in other professional sports. Strength and conditioning certifications were held more commonly than SCCs in swimming (58%) [20] and rugby union (56%) [19]. Furthermore, over half of SCCs also had soccer coaching certifications, which has not been addressed in prior surveys. Obtaining a recognized strength and conditioning certification is considered important for personal development, quality assurance and employability [3, 24, 25]. Whereas soccer certifications provide underpinning theoretical and practical expertise, allowing SCCs to utilize their strength and conditioning knowledge to program soccer specific exercises and activities [1, 3]. Most notably, a quarter of SCCs held a PhD which is considerably higher than reported in prior surveys across different sports [11, 19]. The level of academic qualifications held by this generation of SCCs is possibly supported by higher education programs building stronger links with professional strength and conditioning organizations and sports teams [26]. Whereas, to obtain a job as a SCC it is often a prerequisite for candidates to possess higher degrees in a related field [24, 25], particularly in professional sport. In support of transitioning from academia to the workplace, it was observed a high percentage of SCCs completed an internship. This is unsurprising given internships allow progressing SCCs to apply theoretical and practical knowledge/skills, improve self-efficacy, develop soft skills, and increase employment opportunities [3, 27, 28].

Periodization strategies were extensively used by SCCs in professional soccer, and to a larger extent than reported in other professional sports 69–91% [15–19]. Research has demonstrated in professional soccer, the use of block periodization over four seasons, improved performance (i.e., points tally), which was attributed to an increased focus on sport-specific speed development during the re-

TABLE 4a. Strength and conditioning coach responses to the biggest issues faced in their role.

Rank	Theme	Exemplar Responses	Percentage of Coaches (*n* = 52)
1	Time / Scheduling / Fixtures	"Expectations for long working hours (e.g., travel, preparation)" and "Frequency of match days, at least 51 match days in-season not including cup progression".	29%
2	Training Load / Periodization	"Limited recovery time, balancing S&C practices with tactical and technical work due to limited training days" and "Managing load in congested fixture schedules between key and bench players".	27%
3	Colleague Relationship / Opinion Differences	"Communication and buy-in from the head coach" and "Finding common objectives with the sports coaches".	23%
4	Miscellaneous	"Long term athlete development compliance" and "Lack of players' education related to work ethic, weightlifting and surrounding components (e.g., nutrition, sleep, recovery). It makes us spend a lot of time fighting (with players, staff, clubs) for basics, when we would like to apply advanced advice / protocols".	21%
5	Lack of Facilities / Equipment / Staffing	"Player:Coach ratio is often a challenge with relatively large playing squads (>20) and low numbers of staff (1–2)" and "Lack of money and people".	15%
6	Individualization of Training	"Differentiation between game-players and reserves" and "Volume of athletes programmed for - thus inability to individualize".	10%

*Some coaches detailed more than one response. Which was further sub-divided amongst the themes created.

TABLE 4b. Strength and conditioning coach responses to the unique aspects of their programs.

Rank	Theme	Exemplar Responses	Percentage of Coaches (*n* = 52)
1	Nothing / Focused on Basics	"Brilliant Basics - we continually strive to get the basics" and "Probably not. I'd be interested to see any program that is labelled unique. The basics done well and consistently is the best formula in my mind".	58%
2	Miscellaneous	"Consequence, respect the demands of the job on the pitch / in the gym" and "We support both academic and sports development until the under 23's age group, therefore, promote holistic development of players".	23%
3	Sport Specific / Individualized Training	"Soccer specific movements and gestures" and "We try to individualize as much as we can, even within collective training sessions".	13%
4	Periodization	"Acceleration, change of direction and agility training is progressed through a continuum" and "We us periodization four our strength and power program, so we do 2 sessions (upper and lower) and currently progressing through a block periodization so will work through 6 weeks of hypertrophy, 6 weeks of max strength and 6 weeks of power.	10%
5	Technology / Player Testing	"Use of technology for simplicity of application through complex systems" and "Integration of test equipment in the training".	6%
6	Research Informed Practice	"Try to use evidence base research integrated within a program" and "I like every year to change the approach with the seniors and see what is new in research".	4%

*Some coaches detailed more than one response. Which was further sub-divided amongst the themes created.

TABLE 4c. Strength and conditioning coach responses to strategies used to individualize training different positions and players.

Rank	Theme	Exemplar Responses	Percentage of Coaches (n = 52)
1	Position Specific Demands to Individualize Training	"Certain positions will work more than others on movements associated to their player profile, e.g., an explosive winger will do more ballistic type stuff, and central midfielder do more lunging type stuff throughout all planes" and "We use GPS to track player load according to the individualized match activity (or position average) and individualized top speed velocity. This allows us to individualize every pitch session (sport related or strength and conditioning) according to the specific needs of each position".	44%
2	Screening / Well Being / Testing	"We try to develop players weaknesses based off pre-screening" and "I use the maximum speed reached during last stage of 30–15 Intermittent Fitness Test (VIFT) to individualize training" and "Based on testing and how the athlete is feeling".	33%
3	Maturity Status / Long Term Athlete Development	"Training is modified off players training age and maturation" and "Each academy player is provided an individual physical development program based on their maturation status".	12%
4	Players Weekly Physical Load	"Individual workloads are prescribed based off match performance (e.g., distance covered, high velocity running)" and "Training is individualized off weekly loads".	10%
5	Miscellaneous	"Normally yes, physical-technical exercises" and "Provide additional sequences (pre- or post-session) of speed/strength/etc exercises to athletes who need them (they ask for it, or we propose to them: it is all about positive communication)".	10%
6	Yes (No Elaboration)	n/a	10%
7	Goal Setting / Athlete Input	"Yes based on athlete goals" and "Athlete input".	8%
8	No	n/a	4%

*Some coaches detailed more than one response. Which was further sub-divided amongst the themes created.

TABLE 4d. Strength and conditioning coach responses to changes or modifications they would make to their programs given unlimited time and resources.

Rank	Theme	Exemplar Responses	Percentage of Coaches (n = 52)
1	Technological Equipment / Testing	"I would invest on sleep monitoring using sophisticated equipment" and "Video technique analysis of sessions, velocity based training".	27%
2	Facilities / Staffing	"We currently perform strength sessions in a circuit because of limited racks available so players are put into specific training groups and rotated weekly to do the session in the optimum order" and "Larger gym and improved coach:athlete numbers".	27%
3	More Time / Training Time with Players	"A Little more time to work on the strength of the athletes to 1) injury proof them and 2) help them maximize performance" and "More opportunities to introduce new stimulus without risk of reduced performance".	17%
4	Individualization	"Yes I would individualize even more deeply, every strength and conditioning session will be individualized for every athlete" and "More attention to detail with each individual".	15%
5	Miscellaneous	"A lot of players and clubs would benefit if they invest more in a long term athletic performance enhance" and "Less time foam rolling, more time building fluid movements through mobility, movement competency types sessions".	15%
6	No	n/a	10%
7	Yes (No Elaboration)	n/a	6%

*Some coaches detailed more than one response. Which was further sub-divided amongst the themes created.

TABLE 4e. Strength and conditioning coach responses to what they believe will be future trends in their job role.

Rank	Theme	Exemplar Responses	Percentage of Coaches (n = 52)
1	Technology	"Less decision making with more artificial intelligence and machine learning" and "Cognitive / virtual reality" and "The combination of wearable technology and video analysis".	21%
2	Individualization	"Training sessions will be more and more individualized. The time to bring all players together to work collectively will reduce in the future" and "More specialized training on position and associated movements".	21%
3	Miscellaneous	"Athletes will be stronger, faster and will have to play more often with congestive fixtures" and "I think more online sessions will occur as a result of COVID-19 and the ability to adapt to this".	21%
4	Testing / Monitoring	"Objective and invisible monitoring for lifestyle (e.g., sleep, nutrition). At the club we know what players do. At home, we can only guess" and "Increase in velocity based training and testing".	13%
5	External Strength and Conditioning Coaching	"Individualized strength and conditioning outside of the club" and "I believe players will build their own performance team and employ individual SCCs".	10%
6	Prehabilitation / Injury Reduction	"Greater understanding of performance profiling and its links to performance and injury risk" and "Increased focus on injury prevention".	10%
7	Back to Basics	"I feel the field will move away from all the data we currently have. Top teams sometimes have more measures than they can make use of, I think teams will go back to basic measures or a limited number of relevant measures" and "Going back to using less tech and back to person to person coaching".	10%
8	Specialized Staff	"Integration of football psychologists" and "Segmentation of all roles, i.e., strength and power coach, speed coach, fitness coach".	6%

*Some coaches detailed more than one response. Which was further sub-divided amongst the themes created.

alization phase [29]. However, SCCs also reported challenges with designing and implementing periodized plans, due to "balancing strength and conditioning practices with tactical and technical work due to limited training days" and "frequency of match days" (see Table 4a. This was apparent in-season where a maintenance approach was adopted by reducing workloads for strength development programs, compared to the off-season. Research suggests a single weekly maintenance session over 12-weeks in professional soccer players maintains strength and power gained during prior developmental periods [30]. Whereas, set loads prescribed by SCCs during strength sessions were mostly athlete dependent. This concurs with open-ended responses, such as: "we try to individualize as much as we can" and "this allows us to individualize every pitch session (sport related or strength and conditioning)" (see Tables 4b and 4c). However, individualized training was a big issue faced by SCCs and something they wanted to further integrate into their programs given unlimited time and resources (see Table 4d).

Concentric and eccentric training were the most common modes of resistance exercises prescribed, whereas other contemporary methods were also used (e.g., isoinertial/flywheel). Research suggests, in-season whole body (i.e., upper body, lower body and core) eccentric-overload training conducted 1–2 times per week with professional soccer players, improves lean mass, half squat power and 40-m sprint time, while reducing fat mass [31]. Yet, more traditionally SCCs believed the most important exercise for professional soccer players was the squat and associated derivatives (see Table 2), which is similar to previous surveys in other professional sports [15–20]. Supportively, developing maximal squat strength during a competitive season in professional soccer players, has shown improved sprint performance over 5, 10 and 20 m [32]. Olympic weightlifting was also widely implemented by SCCs, but less than in other professional sports (88–95%) [15, 16, 18, 19], with the most prescribed lifts being derivatives (i.e., hang clean, jumps shrugs). Derivative lifts can be just as effective for improving athletic movements (e.g., triple extension) when performed with maximum intent, while also being less time demanding and complex to learn [33]. This is potentially a reason for coaches using derivatives more commonly given a reported "lack of time with players", "limited facilities and staffing", and "focusing on the basics" (see Tables 4a, 4b and 4d.

Different speed development exercises were implemented by SCCs in professional soccer (i.e., strength training, plyometrics, maximum

speed training and sport-specific movements). Possibly demonstrating soccer players are being trained across the force-velocity continuum, with the inclusion of sport-specific movements to transfer speed improvements to sports performance. Research in netball has demonstrated that coupling sport specific movements to either strength or power training programs improved throwing velocity by 12.4% and 8.8% respectively [34]. Therefore, suggesting SCCs should utilize sport-specific movements to promote sport-specific high velocity adaptations [34].

Plyometric exercises were mostly prescribed all year round, and used more frequently than in other professional sports (15–57%) [15–19]. The reasons for using plyometrics aligned with research recommendations in professional soccer, to improve lower body power, speed, jump height and reduce injuries [35]. Similar to rugby union plyometrics were mostly prescribed as complex training [19]. However, research in professional soccer has suggested combining strength and plyometric training compared to strength training alone, shows no additional improvements to performance in strength, power and speed tests [36]. Nonetheless, complex training is a time efficient method for integrating strength and plyometric work within the same program [37]. Comparable to American football [15] multiple hops/lunges and bounding, were the most prescribed plyometric exercises in this study. This is logical given these exercises effectively develop the stretch-shortening cycle, enabling soccer players to perform explosive muscular contractions and improve rapid force development [35].

Physically testing players was predominantly conducted during the pre-season, whereas a large proportion of SCCs tested players all year round. It has been shown that significant changes occur in different physical fitness and performance capacities (e.g., lower body power, flexibility, agility, aerobic and anaerobic fitness) across a season in professional soccer [38]. Therefore, monitoring changes in player's physical fitness throughout a season, allows SCCs to provide benchmarks for players returning from injury, observe decrements in performance, and ascertain if physical training programs have been effective [38]. Cardiovascular endurance was the most utilized physical test, which is practical given players peak heart rates reach 85–98% of maximal values and average oxygen uptake is approximately 70% of maximum values in professional soccer matches [4].

Technology-based equipment and in particular GPS was widely used by SCCs in professional soccer. Open-ended questions revealed GPS was used to "track player load according to the individualized match activity (or position average) and individualized top speed velocity". Research recommends tracking total training load, external responses to training load, positional match-play demands, and exposures to high-speed running to optimize training programs and reduce injuries [10]. Also, SCCs in this study commonly monitored athlete-wellbeing, predominantly through mobile device questionnaires. Self-reporting techniques such as informal questionnaires, are valid for players to declare their fatigue and wellbeing levels [39]. Furthermore, this information can be used to have informed discussion with players, and make decisions whether to modify set loads, training intensity, training volume and/or provide player support [39].

Practical applications

To become a SCC in professional soccer, obtaining academic and professional qualifications are of high importance. Whereas, to apply theoretical knowledge and practical skills learnt, SCCs are encouraged to complete an internship, which may increase employment opportunities. Obtaining soccer certifications can provide underpinning knowledge to design and implement sport-specific programs. For example, players should be trained across the force-velocity continuum with the inclusion of sport-specific movements to transfer physical gains to sports performance. To achieve this, periodized training plans are recommended, in order to concurrently develop players key physical capacities, and monitor/modify training loads to cater for congested fixture schedules and soccer skill practices. Squats and deadlifts including associated variations, are considered important exercises for professional soccer players. But it is essential that exercises, programs and physical tests should be individualized to develop players according to their position, injury history and weaknesses. Whereas, GPS and subjective measures of athlete-wellbeing provide valuable information to inform decisions made by SCCs regarding the design and modifications to strength and conditioning programs, with the overall aim of improving performance and reducing injuries.

CONCLUSIONS

Compared to previous surveys in professional sport, SCCs in soccer more frequently used periodized training programs and plyometrics exercises. Whereas, they similarly reduced workload in-season to adopt a maintenance approach, and prescribed Olympic weightlifting exercises less often. This study provides new evidence that SCCs in professional soccer can use to review current practices and also provide new ideas for diversifying/modifying future practices. Whereas, graduates or SCCs wanting to work in professional soccer may tailor their continued professional development to align with contemporary practices outlined.

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Conflict of interest

No conflict of interest is declared.

APPENDIX 1.

SURVEY: CONTEMPORARY PRACTICES OF STRENGTH AND CONDITIONING COACHES IN PROFESSIONAL SOCCER

■ Refers to questions with multiple choice answers
● Refers to questions with single choice answers

Other: Was provided for a number of questions in order for participants to provide specific answers, if their practices are different to the pre-determined answers, or if they wished to further elaborate on their answers.

A) Background Information

Q1. Which country are you currently based?

Q2. Gender?

Q3. Age?

Q4. Number of years' experience as a strength and conditioning coach?

Q5. Which league do you currently work in?

Q6. What is your highest level of education?
- Bachelor's Degree
- Master's degree
- PhD
- Other

Q7. Was your degree in a sports science related field? If not, please write your degree below.
- Yes
- No
- Other

Q8. What professional strength and conditioning qualification(s) do you hold?
- ■ Australian Strength and Conditioning Association (ASCA)
- ■ National Strength and Conditioning Association (NSCA)
- ■ Strength and Conditioning Coach Certified (CSCCA)
- ■ United Kingdom Strength and Conditioning Association (UKSCA)
- ■ None
- ■ Other

Q9. What professional soccer coaching qualification(s) do you hold? Write your qualification in other.
- None
- Other

Q10. Have you completed a strength and conditioning internship? Any duration is acceptable.
- ■ Yes (Before certification)
- ■ Yes (During certification)
- ■ Yes (After certification)
- ■ No

B) Muscular Strength and Power Development

Q11. Off-Season: How many strength training sessions do you deliver on average each week?

■ 1	■ 9	■ 17
■ 2	■ 10	■ 18
■ 3	■ 11	■ 19
■ 4	■ 12	■ 20
■ 5	■ 13	■ 21
■ 6	■ 14	■ Other
■ 7	■ 15	
■ 8	■ 16	

Q12. Off-Season: What is your average length per strength training session?
- ■ 0–15 minutes
- ■ 16–30 minutes
- ■ 31–45 minutes
- ■ 46–60 minutes
- ■ 61–75 minutes
- ■ 76–90 minutes
- ■ 90+ minutes
- ■ Other

Q13. Off-Season: What is your typical set range for each exercise in strength training sessions?

■ 1–2	■ 7–8	■ Other
■ 3–4	■ 9–10	
■ 5–6	■ 10+	

Q14. Off-Season: What is your typical repetition range for each exercise in strength training sessions?

■ 1–3	■ 10–12	■ Other
■ 4–6	■ 13–15	
■ 7–9	■ 15+	

Q15. In-Season: How many strength training sessions do you deliver on average each week?

■ 1	■ 9	■ 17
■ 2	■ 10	■ 18
■ 3	■ 11	■ 19
■ 4	■ 12	■ 20
■ 5	■ 13	■ 21
■ 6	■ 14	■ Other
■ 7	■ 15	
■ 8	■ 16	

Q16. In-Season: What is your average length per strength training session?
- ■ 0–15 minutes
- ■ 16–30 minutes
- ■ 31–45 minutes
- ■ 46–60 minutes
- ■ 61–75 minutes
- ■ 76–90 minutes
- ■ 90+ minutes
- ■ Other

Q17. In-Season: What is your typical set range for each exercise in strength training sessions?
- ■ 1–2
- ■ 3–4
- ■ 5–6
- ■ 7–8
- ■ 9–10
- ■ 10+
- ■ Other

Q18. In-Season: What is your typical repetition range for each exercise in strength training sessions?
- ■ 1–3
- ■ 4–6
- ■ 7–9
- ■ 10–12
- ■ 13–15
- ■ 15+
- ■ Other

Q19. How do you determine set loads?
- ■ Repetition maximum
- ■ Predicted repetition maximum
- ■ Trial and error
- ■ Train to failure
- ■ Subjective / Guess
- ■ Athlete dependent
- ■ Ratings of Perceived Exertion (RPE)
- ■ Velocity (e.g., accelerometer)
- ■ Do not determine
- ■ Other

Q20. Do you periodize training?
- • Yes
- • No
- • Other

Q21. How much recovery time do you prescribe between strength and conditioning training, sports training and competition?

	On the Same Day	24 hr	36 hr	48 hr	>48 hr
Recovery time between speed development and sports training session					
Recovery time between strength / power development and sports training session					
Recovery time between speed development and competition					
Recovery time between strength / power development and competition					

Q22. Which Olympic weightlifting exercises or derivatives do you use in your training programs?
- ■ Clean
- ■ Jerk
- ■ Snatch
- ■ Power clean
- ■ Power snatch
- ■ Power jerk
- ■ Hang clean
- ■ Hang snatch
- ■ Clean high pull
- ■ Snatch high pull
- ■ Jump shrugs
- ■ Do not use
- ■ Other

Q23. Which methods of resistance do you commonly use within your training programs?
- ■ Concentric
- ■ Eccentric
- ■ Isometric
- ■ Machine
- ■ Variable (e.g., bands, chains)
- ■ Isoinertial (e.g., flywheel)
- ■ Other

Q24. What is the FIRST most important weightlifting exercise you prescribe in your training program?

Q25. What is the SECOND most important weightlifting exercise you prescribe in your training program?

Q26. What is the THIRD most important weightlifting exercise you prescribe in your training program?

Q27. What is the FOURTH most important weightlifting exercise you prescribe in your training program?

Q28. What is the FIFTH most important weightlifting exercise you prescribe in your training program?

C) Speed Development

Q29. Which methods do you commonly use for speed development?
- ■ Speed running
- ■ Form running
- ■ Resisted running
- ■ Overspeed running
- ■ Maximum speed sprinting
- ■ Plyometrics
- ■ Olympic Weightlifting
- ■ Strength training
- ■ Sport specific movements
- ■ Circuit training
- ■ Interval training
- ■ Uphill/downhill running
- ■ Do not use
- ■ Other

D) Plyometrics

Q30. What are the main reason(s) you use plyometrics for in your program?
- ■ Total body training
- ■ Lower body power
- ■ Upper body power
- ■ Speed development
- ■ Improve jumping ability
- ■ Injury reduction
- ■ Do not use
- ■ Other

Q31. What stages of the year do you use plyometrics?
- ■ All year round
- ■ Pre-season
- ■ In-season
- ■ Off-season
- ■ Training camp
- ■ Do not use
- ■ Other

Q32. When do you predominantly integrate plyometrics?
- ■ Separate days
- ■ Before weights
- ■ After weights
- ■ Complex training
- ■ Do not use
- ■ Other

Q33. Which plyometric exercises do you commonly integrate into programs?
- ■ Bounding
- ■ Box drills
- ■ Depth jumps
- ■ Jumps in place
- ■ Multiple hops / lunges
- ■ Standing jumps
- ■ Upper body plyometric
- ■ Do not use
- ■ Other

E) Flexibility Development

Q34. When are athletes encouraged or required to perform flexibility exercises in your program?
- ■ After practice
- ■ Before practice
- ■ During practice
- ■ Independently / On their own
- ■ Before workout
- ■ During workout
- ■ After workout
- ■ Do not use
- ■ Other

Q35. What are the most common forms of flexibility training that you use?

	Never	Sometimes	Commonly
Ballistic			
Dynamic			
Active			
Passive			
Static			
Isometric			
PNF			

Q36. What is your average length per flexibility session?
- • 0–5 minutes
- • 6–10 minutes
- • 11–15 minutes
- • 16–20 minutes
- • 21+ minutes
- • Do not perform
- • Other

F) Physical Testing

Q37. When do you physically test athletes?
- ■ All year round
- ■ Pre-season
- ■ In-season
- ■ Off-season
- ■ Training camp
- ■ Do not test
- ■ Other

Q38. Which of the following physical tests do you use with your athletes? You may write specifically which tests in 'other'.
- ■ Body composition
- ■ Muscular strength
- ■ Cardiovascular endurance
- ■ Anaerobic capacity
- ■ Speed
- ■ Muscular power
- ■ Agility
- ■ Flexibility
- ■ Acceleration
- ■ Muscular endurance
- ■ Anthropometry
- ■ Other

Q39. How do you monitor an athlete's well-being?
- ■ Mobile phone or tablet application
- ■ Verbal questionnaire
- ■ Written questionnaire
- ■ Do not monitor
- ■ Other

G) Technology Use

Q40. Which technology-based equipment do you use in your training programs?

- Electronic jump mat
- Bar velocity tracker
- Global positioning system (GPS)
- Mobile phone applications
- Speed gates
- Body composition analyzer
- Hear rate monitor
- Video analysis software
- Force plates
- Metabolic analysis device
- Wearable technology (e.g., smart watch)
- Do not use
- Other

H) Programming

Q41. What is the biggest issues you face as a strength and conditioning coach?

Q42. Do you feel there is anything unique about your program?

Q43. Do you employ any strategies to individualize training for different positions and athletes?

Q44. Given unlimited time and resources, is there anything you would change in your program?

Q45. What do you feel will be a future trend in strength and conditioning?