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The strength and conditioning practices and perspectives of coaches and athletes, across different sports, countries, and levels.

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Abstract

This critical review includes a portfolio comprising seven outputs, published in international peer-reviewed journals from 2020-2022. The connected theme between outputs is the practices and perspectives of strength and conditioning (S&C) coaches, sports coaches, and athletes across different sports, countries, and levels. This theme links substantially to the author's experience in higher education and applied settings. Each output provides primary evidence for the selected sports and populations, including extensive information on participant demographics, strength, power, speed, programing, physical testing, and technology use. Within each output the results are comprehensively discussed, offering rare insight as to whether the S&C practices and perspectives of S&C coaches, sports coaches, and athletes are research-informed or if anecdotal methods are preferred. Collectively these outputs create an important resource for practitioners and researchers in S&C, which can be used as a point of reference, guidance, or comparison. The findings from each output have been disseminated through conference presentations, higher education teaching resources, and industry collaborations, leading to an incremental impact being made regionally (Hong Kong) and internationally.

Objectives

This portfolio investigates the practices and perspectives of strength and conditioning (S&C) coaches, sports coaches, and athletes across different sports, countries, and levels. Which aims to fulfill the following objectives:

1. To identify contemporary S&C practices used in various sports and determine whether these align with S&C guidelines and research.
2. To investigate literature and research regarding S&C practices and perspectives, and the influence of sport, country, and level.
3. To highlight research gaps and critique the impact this has on the development of S&C.
4. To conclude the impact and implications of the research examined and outputs conducted, and propose further areas of research.

Each objective derives from the following outputs, forming this portfolio:

1. **Weldon, A**., Duncan, M. J., Turner, A., LaPlaca, D., Sampaio, J. & Christie, C. J. Practices of strength and conditioning coaches: A snapshot from different sports, countries and levels. *Journal of Strength Conditioning Research* (2020) doi: 10.1519/JSC.0000000000003773.
2. **Weldon, A**., Duncan, M. J., Turner, A., Wong, D. P., Noon, M., Sampaio, J. & Lai, V. W. Contemporary practices of strength and conditioning coaches in professional soccer. *Biology of Sport.* **38**, 377–390 (2020).
3. **Weldon, A**., Duncan, M. J., Turner, A., Christie, C. J. & Pang, C. M. C. Contemporary practices of strength and conditioning coaches in professional cricket. *International Journal of Sports Science and Coaching*. **16**, 585–600 (2020).
4. **Weldon, A**., Duncan, M. J., Turner, A., Lockie, R. & Loturco, I. Practices of strength and conditioning coaches in professional sports: a systematic review. *Biology of Sport.* **39**, 715–726 (2021).

5. **Weldon, A**., Mak, J. T. S., Wong, S. T., Duncan, M. J., Clarke, N. D. & Bishop, C. Strength and conditioning practices and perspectives of volleyball coaches and players. *SPORTS* (2021) doi.org/10.3390/sports9020028.
6. **Weldon, A**., Wong, S. T., Mateus, N., Duncan, M. J., Clarke, N. D., Pears, M., Owen, A. L. & Bishop, C. Practices and perspectives of strength and conditioning in soccer coaches and players. *International Journal of Sports Science and Coaching* (2022) doi.org/10.1177/17479541211072242.
7. Loturco, I., Freitas, T. T., Alcaraz, P. E., Kobal, R., Nunes, R., **Weldon, A**. & Pereira, L. A. Practices of strength and conditioning coaches in Brazilian elite soccer. *Biology of Sport.* **39**, 779–791 (2021).

Chapter 1: Autobiographical information and portfolio development

1.1 Autobiographical context for the portfolio and outputs

Initial discussions for the outputs forming this portfolio were held in 2019 with Prof. Michael Duncan at the European College of Sport Science Annual Congress in Prague. Whereas the underpinning knowledge and development of ideas stem from my 17 years of international experience as an educator, researcher, and practitioner in strength and conditioning (S&C) and associated fields.

Personally, my S&C practices and perspectives are continually influenced by the theoretical knowledge and practical skills obtained from academic and professional courses, alongside industry experience. An early example of this would be in 2011 during my master's degree at Coventry University, where I was concurrently employed as an intern with British Fencing and S&C coach working with Coventry University's scholarship athletes. Through my university education, I learned how to design a physical testing battery and use the results to individualize a training program for athletes. However, I had limited experience applying this in a real-world setting. Therefore, the lead S&C coach for British Fencing Assoc. Prof. Anthony Turner, guided me through this process using a fencing-specific framework for age-grade athletes. Hereafter, I adapted the aforementioned framework when working with scholarship athletes (e.g., dinghy sailing, boxing, rugby). This emphasized the applicability of fundamental S&C practices irrespective of the sport and level. Through gaining these valuable experiences, my perspectives regarding the roles and responsibilities of S&C coaches changed. I became more aware of achieving the basics very well and the need to establish stronger soft skills (e.g., communication, listening, and negotiation). Collectively this improved my ability to obtain buy-in and support from coaches and athletes, thus increasing the success of my S&C programs.

In 2015, I moved to Hong Kong as a lecturer on the BSocSc in Sports and Recreation Management Program at the Technological and Higher Education Institute of Hong Kong (THEi) and shortly after was promoted to senior lecturer and head of the sports coaching discipline. I was given the responsibility to convene several S&C related modules, which I revamped the curriculum to become more contemporary and industry-connected. This was possible through the S&C practitioner and consultancy roles I held with regional National Sports Associations (NSAs) including Hong Kong

Rugby Union, Hong Kong Hockey Association, and Cricket Hong Kong (CHK). Each NSA was embedded within the curriculum of our degree program via work experience opportunities and each team was based on campus either part- or full-time. These ongoing collaborations enable my students to practically apply their theoretical understanding of S&C concepts in high-performance environments with diverse sporting populations. Furthermore, provides students the opportunity to recruit professional athletes as participants in their undergraduate dissertation projects to produce meaningful and actionable research. Reminiscent of my development, I have witnessed students develop their ability to design, deliver, and evaluate S&C programs for various sports. While their S&C practices and perspectives have matured and broadened with these experiences.

To upskill students, staff, and industry partners in S&C and related areas, I frequently run internationally recognized certifications and accreditations in Hong Kong with organizations such as World Rugby, EXOS, British Weightlifting, USA Basketball, etc. The content delivered in these courses expand beyond local culture, curricula, and education resources. Therefore, enable participants to experience different coaching systems and learn from the practices and perspectives of international educators. Accordingly, these opportunities complement students' formal development of theoretical knowledge and practical skills in S&C obtained from their degree studies. Moreover, I led an application to become the first-degree program in Hong Kong to be accredited under the National Strength and Conditioning Association (NSCA) Education Recognition Program. This has fostered several graduates to complete master's degrees in S&C at Coventry and Middlesex Universities (England), and obtain their NSCA Certified Strength and Conditioning Specialist (CSCS) accreditations. These students have since returned to Hong Kong and now work in S&C and associated areas. To acknowledge my holistic development of students, academically and professionally, I was awarded a Senior Fellowship of the Higher Education Academy (SFHEA) in 2019.

Hereafter, I have made a concerted effort to develop my research ability, experience, and output. Although my research interests span from higher education to sports coaching, my main focus is S&C. Through concurrently holding academic and consultancy-based roles, I mostly conduct applied research, whereby my practice and research inform one another. A key focus of my research is to engage and encourage S&C coaches, sports coaches, and athletes to critically reflect on their application and

participation in S&C. To make my research more accessible I disseminate my findings through various channels (e.g., conference presentations, higher education teaching resources, and industry collaborations). To date, I have published 23 peer-reviewed publications, presented at 9 international conferences, and achieved 8 research grants and awards. My progress as a researcher was recently recognized by the Australian Strength and Conditioning Association (ASCA), where my conference presentation 'Current issues, desired changes, and future trends: opinions of S&C coaches in professional soccer and cricket' won the junior researcher award.

1.2 Development of the portfolio of evidence

This critical review addresses the emerging field of S&C, including valuable insight into the roles, responsibilities, practices, and perspectives of S&C coaches, sports coaches, and athletes.

Sport continues to grow in stature, particularly at the professional level, leading to more funds available for employing multidisciplinary athlete support teams [1–3]. Within these teams, staff are appointed to cover different technical, medical, sports science, and physical training positions [4]. An increasingly prominent role across all levels of sport is the S&C coach, who handles various areas of athlete preparation [5,6]. Consequently, S&C coaches should have a general understanding of other departments within the athlete support team (e.g., sports therapists and sports coaches) [5]. The primary objectives of a S&C coach are to apply their theoretical and practical knowledge in S&C to different sports, to improve athletes' physical performance, and decrease injury occurrence [6]. For S&C coaches to obtain and develop the required knowledge and practices in S&C a wealth of literature and research is available. However, comparatively little research has investigated what practices S&C coaches actually employ. This limited understanding has been exemplified by a recent study highlighting the lack of clarity and consistency of job specifications for S&C coaches (i.e., knowledge, experience, and education requirements) [7]. This ambiguity makes it inherently difficult for S&C coaches to establish which areas are most important to focus on and develop [7]. Therefore, establishing a stronger evidence base that presents demographic information (e.g., qualifications and experience) and investigates the practices and perspectives of S&C coaches, is needed. It is aimed that all outputs within

this portfolio help fill this void, and provides much-needed insight into the discipline of S&C for practitioners, researchers, and governing bodies.

To date, the research published on the practices of S&C coaches has predominantly been conducted in professional sports and individual countries, including American football [8], ice hockey [9], baseball [10], and basketball [11] in North America, wrestling [12] in Iran, and cricket in South Africa [13]. Whereas, until the publication of outputs [1-3] the practices of S&C coaches across multiple countries had only been investigated in rugby union [14] and swimming [15]. Although the aforementioned research provides valuable insight, which is drawn upon in output [4], there are still numerous sports and countries underrepresented. Consequently, outputs [1-3, 5-7] broaden the scope of sports and countries investigated. This has been possible using the strong foundation and framework provided by these prior studies [8–15] to develop appropriate methods for further surveying S&C coaches.

All outputs within this portfolio have been informed by my applied practice and experience in sport, from grassroots to professional level, in Europe, North America, and Asia. My experiences have revealed that S&C provisions are not always delivered by qualified S&C coaches, particularly at sub-elite levels and in countries where S&C is still evolving (e.g., Hong Kong). Consequently, sports coaches, support staff, and athletes are often tasked with this responsibility. To address this matter, there is a growing body of research investigating the S&C practices of sports coaches and athletes, including school sports team coaches [16], rowing coaches [17], cricket coaches [18], rugby union coaches [19], sprint coaches [20], rugby athletes [21], strongman athletes [22], stock car athletes [23], and distance running athletes [24]. Beyond providing insight into these populations, these studies raise valid questions about the suitability and expertise of sports coaches and athletes to be conducting S&C independently. Therefore, it is important to investigate this issue in other sports and countries, to obtain a comprehensive understanding of whether qualified S&C coaches are employed or not, and how best to support the implementation of safe and effective S&C provisions. This is a specific focus of outputs [5-6], which were undertaken in Hong Kong soccer and volleyball. The region of Hong Kong is of personal interest given this is where I work and consult in S&C.

An area underreported in prior research is the responses of S&C coaches, sports coaches, and athletes to open-ended questions regarding their S&C practices and perspectives. This is needed as it allows respondents to provide highly informative and

tailored answers to questions. Therefore, six outputs [1-3, 5-7] within this portfolio provide original contributions by comprehensively reporting open-ended responses from S&C coaches, sports coaches, and athletes. This develops a unique understanding of the rationale and context as to why certain S&C practices are employed and perspectives held. Furthermore, allows a more comprehensive interpretation of whether S&C practices and perspectives align with recommendations from contemporary S&C guidelines and research. Practices and perspectives deviating from these recommendations are critically discussed, and the impact of anecdotal evidence, experience, country, and culture, are considered. Furthermore, with the rapid evolution of S&C and integration of new methods and technologies used to train, monitor, and report athlete's data [25], it is advised that research within the field of this portfolio also investigates the perceived future of S&C. This is a novel area reported within outputs [1-3, 7].

The need and scope for the research included in this portfolio have been underpinned by the gaps present in the existing literature and the need for a broader representation of S&C practices and perspectives across all sports, countries, and levels.

Chapter 2: Presentation, evaluation, and synthesis of outputs

2.1 Description, synthesis, and evaluation of links between outputs and the development of the portfolio of evidence

This section provides a link between outputs forming this portfolio and discusses key findings. Figure 1 illustrates the contribution of each output with the overarching theme of this portfolio, which is to broadly investigate S&C practices and perspectives, across different sports, countries, and levels. The perspectives shared concerning each output include my personal views based on my experience as an educator, researcher, and practitioner in S&C.

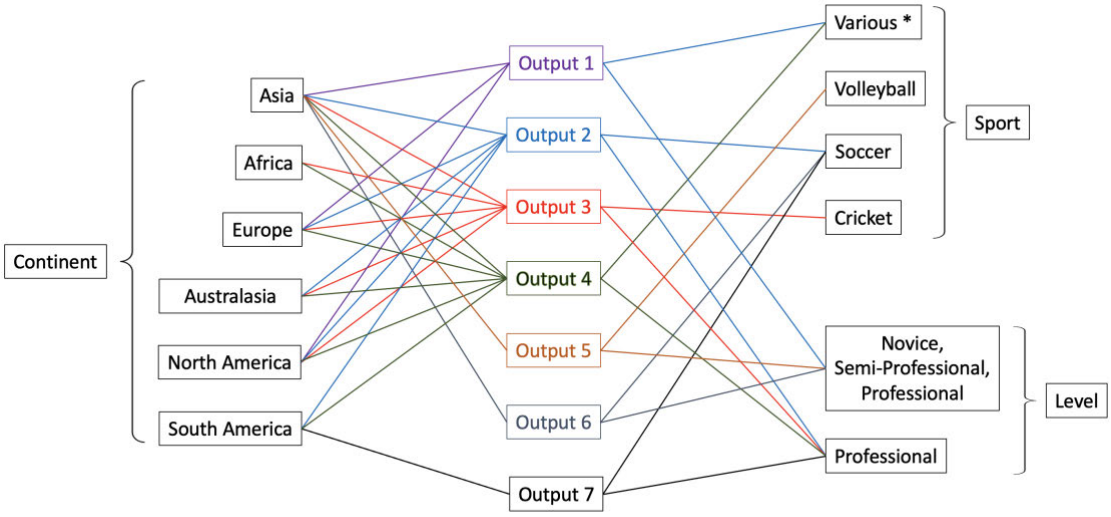

Figure 1. An overview and global representation of outputs forming the portfolio of evidence across different sports and levels.

*Outputs [1, 4] covered various sports, which are specifically detailed within these respective outputs.

Output [1] created a firm basis for all proceeding outputs in this portfolio, using a comprehensive survey to investigate the practices and perspectives of S&C coaches, with topics ranging from muscular strength and power development to future trends in S&C. Findings from this study, revealed that S&C coaches were employed across

various sports (e.g., basketball to horse racing), levels (e.g., high-school to professional), and countries (e.g., the United Kingdom to China). Consequently, the new evidence presented within output [1] provides a basis to make informed suggestions and guidelines regarding S&C practices for these diverse populations. Output [1] underpinned subsequent outputs [2-3, 5-7] which further investigated underrepresented sports (i.e., soccer, cricket, and volleyball), countries (i.e., Hong Kong and Brazil), and personnel (i.e., sports coaches and athletes). Specifically, outputs [2-3] focused on professional soccer and cricket, two global sports where the practices and perspectives of S&C coaches had yet to be explained. These sports were targeted, given my extensive experience as a player and coach in soccer, and my current role as sports performance lead for CHK. Findings from outputs [2-3] led to the conception of the systematic review conducted for output [4] and were included as reviewed papers. Output [4] provides an exhaustive and critical review of the practices of S&C coaches in professional sports against associated guidelines and literature, which serves as a one-stop paper for S&C coaches to obtain such information. In turn, this will help S&C coaches overcome "*a lack of time*" when trying to source and access such information, which was a common issue reported across outputs.

Through personal experience and discussions with sports coaches and athletes in Hong Kong, it became apparent that S&C provisions were commonly delivered independently. After liaising with various NSAs, Hong Kong volleyball and soccer associations were keen to further explore this issue, to better support their implementation of S&C. Therefore, respective surveys were designed and distributed within each NSA to registered coaches and players. Accordingly, outputs [5-6] investigated the S&C practices and perspectives of coaches and players in Hong Kong volleyball and soccer. Whereas, to build upon output [2] and broaden the scope of this portfolio, discussions with Brazilian researchers led to output [7], which investigated the practices of S&C coaches in professional Brazilian soccer. Collectively, outputs [5-7] help provide a different cultural view regarding S&C practices and were the first to address this in Hong Kong and Brazil. Findings in output [7] led to specific recommendations for training Brazilian soccer players, some of which deviated from common practices observed in other related outputs. For example, only 29% of S&C coaches in professional Brazilian soccer used Olympic weightlifting and associated derivatives, contrasting with output [2] that showed 67% of S&C coaches working in different professional soccer leagues and countries adopted these exercises.

The outputs within this portfolio provide extensive information that is useful for S&C coaches working in different levels, sports, and countries, to reference, compare, or develop their existing S&C practices. Furthermore, the inclusion of sports coaches and athletes within outputs [5-6] strengthens our understanding of the delivery of S&C within a multidisciplinary team. A novel finding from outputs [2-3] was that a large proportion of surveyed S&C coaches also possessed soccer and cricket coaching certifications. Thus suggesting S&C coaches may adopt a transdisciplinary approach to their practice, whereby S&C and sports coaching are combined to deliver integrated sports conditioning sessions.

Outputs [1-3, 5-7] demonstrated that most S&C coaches, sports coaches, and athletes held relevant degrees in sports-related disciplines, but to less extent held S&C accreditations (e.g., NSCA CSCS). This was most apparent in outputs [5-6], where although S&C was deemed *"important"* to *"very important"* for physical development, sports skill development, and injury reduction, very few qualified S&C coaches were employed to work within Hong Kong volleyball and soccer. The reported reasons were broad-ranging, from financial issues to a lack of available S&C coaches. Nevertheless, employing an S&C coach with relevant academic and professional qualifications is necessary for various reasons, including safety and quality of provisions. Consequently, conclusions across outputs suggested that S&C governing bodies and NSAs could more proactively provide worldwide education and accreditation pathways for those responsible for delivering S&C. This is a challenging task, but ultimately will increase the safety and quality of S&C across different countries, sports, and levels. However, research investigating the job and person specifications for S&C roles, highlighted that 73% of employers requested a degree or higher, and only 45% requested professional accreditations [7]. Therefore, the requirements to obtain employment as an S&C coach remain unclear, and whether obtaining professional accreditations is essential or desirable to employers.

2.2 Evaluation of the originality of each output

The work included within this portfolio has demonstrated through the review process and publication in reputable international journals, that it is original and adds value to the existing literature in S&C and associated fields. Although, the term originality is difficult to define, and in the context of a Ph.D. is broadly seen as "*the production of*

new knowledge" [26]. According to guidelines and research from Phillips & Pugh [27], a method for determining the originality of work produced by a Ph.D. is to critically evaluate areas that are important contributors to originality. These include conducting empirical work that has not been undertaken before, trying something out in countries that have been done only elsewhere, looking at areas not previously explored in a particular discipline, and synthesizing things that haven't been put together before. Each output within this portfolio partly or completely fulfills each of the aforementioned criteria, demonstrating novel and original content, which extends our understanding and knowledge of S&C as a profession.

Overview of strength and conditioning.

Strength and conditioning has rapidly developed in recent years, with S&C coaches now commonly employed within multidisciplinary athlete support teams [1,4,28]. The main aims of a S&C coach are to optimize athletes' physical and sports performance while limiting injury occurrence [6]. Accordingly, S&C coaches require strong theoretical knowledge and practical ability in various areas (e.g., sports coaching and sports science), as their roles and responsibilities can vary considerably (e.g., integrated sports conditioning to data analytics) [6]. The expectations of S&C coaches are also increasing, particularly with the advancements and integration of technology into daily monitoring and decision-making processes (e.g., global positioning systems [GPS] and athlete management systems) [25]. Whereas for S&C coaches to develop their knowledge and practice, undertaking discipline-specific academic (e.g., master's degree) and professional (NSCA CSCS) qualifications are recommended, while concurrently remaining connected with contemporary guidelines and research [6,7,29]. With the broad and increasingly challenging roles and responsibilities given to S&C coaches (particularly in professional sports), it is becoming inherently important to further investigate and understand their backgrounds, practices, and perspectives.

Output [1] *Practices of strength and conditioning coaches: A snapshot from different sports, countries, and expertise levels.*

Prior research exploring the practices and perspectives of S&C coaches has predominantly been conducted in North American professional sports [8–11]. Although

there is an emergence of studies investigating other regions and populations in professional sport [12,14,15,17], there remains a substantial population of S&C coaches underrepresented. The need for a broader representation of the practices and perspectives of S&C coaches is exemplified by the NSCA now possessing over 60,000 members across 72 countries [30], and with S&C roles evolving from exclusively in professional sport to other areas (e.g., health-related exercise) [29]. Furthermore, there is an overwhelming amount of literature advising S&C coaches on what constitutes best practice, but comparatively, little research has investigated what practices are employed, and importantly why.

Therefore, a deeper understanding of the backgrounds, practices, and perspectives of S&C coaches across sports, countries, and levels is needed. This will provide a clearer demographic understanding of S&C coaches and offer information to improve the alignment between industry requirements, education providers, and developing practitioners. It was recently reported that job advertisements for S&C coaches in North America, the United Kingdom, China, Singapore, and New Zealand were often equivocal and lacked consistency, making it difficult for applicants to align with these roles [7]. Therefore, it is valuable to provide a greater comprehension of the roles, responsibilities, and qualifications that S&C coaches should pursue or develop.

Further evidence is also required to address whether common practices and perspectives of S&C coaches align with recommended guidelines and contemporary research. This should be of particular interest to governing bodies (e.g., NSCA) and researchers. Consequently, this information can provide a basis for justifying or modifying guidelines, while also directing future research areas that are presently anecdotal or novel. For example, the NSCA suggests general and sport-specific physical testing should be conducted to ascertain athletes' current physical condition, which can inform objective decisions on the design and individualization of S&C training programs [31,32]. However, in Major League Baseball (MLB) [10], it was reported that less than one-third of S&C coaches physically tested muscular strength, power, and speed. This is surprising given the importance of these physical attributes for pitching and batting performance [33,34]. However, it was uncertain whether this was intentional, or if external factors such as the demands of intensive schedules and long-playing seasons limited the time available for physical testing [35]. Highlighting such discrepancies and further investigating whether these are attributable to specific sports

and levels is important to provide a deeper understanding of why certain S&C practices are employed, or in this case not.

The originality demonstrated within output [1] stems from its broad reach of S&C coaches across different sports, countries, and levels. Responses from 156 S&C coaches, across 48 sports, and 17 countries, makes it the most comprehensive published survey of S&C coaches to date. This includes responses from sports and countries (e.g., soccer and China), that had yet to be investigated. The demographic information presented in output [1] informs developing and existing S&C coaches, the level of academic and professional qualifications, and S&C accreditations others in the field possess. For example, 99% of respondents held a degree or higher and 71% held S&C accreditations. This raises an important debate on the employability of S&C coaches without professional accreditations (e.g., NSCA CSCS). The findings from output [1] coincide with a comprehensive review of 51 S&C job specifications, which revealed that 55% did not determine S&C accreditations essential [7]. Accordingly, the UKSCA has acknowledged the rapid rise in popularity of S&C and the need for developing professional standards [28]. Therefore, are currently developing professional standards with the Chartered Institute for the Management of Sport and Physical Activity (CIMSPA) [28] to further professionalize the UK S&C industry. These professional standards will enable employers to suitably and consistently specify the requirements for fulfilling different levels of S&C roles [28]. So, S&C coaches may more willingly undertake professional accreditations if the jobs being pursued explicitly require this.

The main focus of output [1] is the practices and perspectives of S&C coaches. Each of the surveyed topic areas builds on prior research from Ebben and colleagues [8–11], and includes original and contemporary questions, such as "*what do you feel will be a future trend in S&C*" and "*how do you monitor athletes' wellbeing*"? The survey used in this output provides extensive quantitative and qualitative results addressing key areas of S&C, from physical testing to programing strategies. This makes the findings broadly applicable across S&C, and adaptable to various individual and team sports. Furthermore, the survey used was published with the paper, to provide additional transparency and context for the responses to each question, and a framework for other researchers looking to contribute to this area of research.

Output [2] *Contemporary practices of strength and conditioning coaches in professional soccer.*

Output [2] provides an original contribution to existing literature, by being the first to report the practices and perspectives of S&C coaches working in professional soccer, and across different countries and leagues.

The lack of research and data on this topic area is surprising given the global popularity of soccer, which has approximately 265 million registered players according to The Fédération Internationale de Football Association (FIFA) [36]. At the professional level, winning games, leagues, and competitions are essential given the financial income derived from television rights, spectatorship, and prize money [2,37]. Due to these financial incentives, there is a growing focus on areas underpinning soccer performance and injury reduction, which has led to the rise of the S&C coach, who is responsible for developing the physical and physiological ability of players [38].

A traditional view of S&C coaches is that they are solely responsible for designing and delivering weight training programs [5]. However, this is misleading given that S&C coaches require a broad understanding and practical ability in biomechanics, bioenergetics, psychology, nutrition, physical testing, rehabilitation, etc [39], which are applied to meet the specific demands of different sports and athletes. Furthermore, to enable closer integration of S&C and soccer-specific training (e.g., tactical and mental training), it is recommended that S&C coaches also obtain soccer coaching certifications and playing experience [38,40]. Irrespective of the practices employed by S&C coaches, it is advised they adhere to S&C guidelines and research that are proven to improve players' physical and sporting abilities [6,38,40]. For example, small-sided games, repeated sprint ability, and repeated change-of-direction drills can improve aerobic and anaerobic capacities, while resistance training and plyometrics can improve strength, power, and agility [38].

Applying practices generally across a soccer team may sometimes be applicable, but an important consideration is the individualization of training methods to meet each player's specific needs [41,42]. This may be influenced by individual differences (e.g., physical ability, age, injury history, and morphological characteristics) and different physical demands across playing positions (e.g., distance covered, high-speed running, and physical contacts) [38,43–45]. Therefore, obtaining relevant information about each player through informal discussion, physical testing, and player monitoring, allows the design, implementation, and periodization of tailored training plans to enhance players' physical and sports performance [46]. These training plans should

continually adapt volume and intensity, to allow the application of recovery strategies through different phases of physical preparation to minimize accumulative fatigue and injury occurrence [40,47]. Although these suggestions are research-informed and likely lead to improved soccer performance, seamless integration is often problematic for various reasons (e.g., congested schedules, fixtures, and time constraints) [42,48,49]. Consequently, to make time-sensitive and informed decisions regarding S&C practices and program design, while promoting data-driven communication with sports coaches and support staff, S&C coaches should monitor each player's training load (internal and external), across S&C training, soccer training, and matches [50].

Although research clearly informs the practical and scientific practices of S&C coaches in professional soccer, there is limited evidence determining whether this applies to real-world settings or if alternative practices are preferred [51]. Similarly, given the growing responsibilities, duties, and expectations placed on S&C coaches at the professional level, a greater understanding of contemporary practices in areas such as data analytics [50,52], supporting and monitoring players' wellbeing [42,53], and injury reduction strategies [42,54], are needed. Output [2], aims to answer these important questions and fill relevant gaps within the literature.

Demographic information presented in Output [2] showed all S&C coaches working in professional soccer held undergraduate degrees and 25% held a Ph.D. Similar findings were also reported in a recent study comparing the strength training methods used in men's vs. women's soccer, where 21% of practitioners responsible for delivering S&C in men's professional first-team soccer also held a Ph.D. [42]. This raises awareness of the important requirement for continued academic development, and how this may influence employability at the highest level. A novel finding of output [2] was more than 50% of S&C coaches also possessed soccer coaching certifications, showing the critical contribution of sports-based knowledge and practice to complement the physical development of players. In general, the implementation of S&C practices reported in output [2] aligned with recommendations in associated literature and guidelines, demonstrating the ability of these S&C coaches to apply theory to practice. Questions surveying the perspectives of S&C coaches also revealed original and interesting findings, that are impactful for professional soccer teams. For example, the detrimental effects of congested schedules, fixtures, and time constraints, on the ability of S&C coaches to deliver appropriate training loads and periodization strategies. Furthermore, how S&C coaches working in professional soccer reported "*focusing on*

the basics" as an essential element of their programing, which is a reassuring message, given the often misconstrued belief of needing to be innovative or different.

This output provides foundational information that can be used to develop further research and education resources for S&C in professional soccer, within the current climate. Furthermore, serves as a source of evidence for existing and progressing S&C coaches in soccer.

Output [3] *Contemporary practices of strength and conditioning coaches in professional cricket.*

Cricket varies from other sports as players are required to participate in different game formats (i.e., Twenty20 [T20], one-day, and multi-day cricket), and at the professional level, may simultaneously play cricket for their club, franchise, and national teams. Furthermore, the rising popularity of shorter game formats (i.e., T20), has increased the match intensity, physical demands, and number of fixtures played [55]. For example, approximately 50-100% more maximal sprints are completed per hour in T20 cricket, when compared with multi-day cricket [56,57]. Consequently, players who can maintain optimal physical conditioning throughout congested fixtures across a season [58], using appropriate physical preparation and recovery strategies, are more likely to consistently perform and reduce the prevalence of injuries [59]. In output [1], S&C coaches across different sports, countries, and levels, recommended using fundamental principles and exercises to provide a strong foundation for S&C programs. The application of this in cricket could be the development of upper-body strength (e.g., bench press, pull-ups) which is associated with enhanced bowling velocity [64], batting distance [60], and resilience to injuries caused by repetitive throwing in the field [61]. However, in professional sports, as observed in output [2], there are additional needs to tailor S&C programs to each player's profile and position [13,51,55]. But based on the available evidence in professional cricket it is uncertain whether theoretical and research-based guidelines are informing the practices of S&C coaches [13].

To date, only one study has investigated the practices of S&C coaches in professional cricket, which was conducted in South African franchise teams [13]. Although this study provided the first insight for S&C coaches in cricket, a sample size of five was a clear limitation [13]. Thus, generalizing the findings from this study to S&C coaches working in different leagues and countries may be unsuitable. So a deeper

understanding of the contemporary practices of S&C coaches working in cricket in a more heterogeneous sample was required, which output [3] provides.

Output [3] builds upon outputs [1-2] to provide a comprehensive overview of the practices of S&C coaches working in professional cricket, across various leagues and countries. As with output [2], the aim and original contribution of this study were to provide insight into the adherence of general and cricket-specific guidelines and research in S&C. A novel finding from this output that has received less attention in the literature, particularly in cricket, was the extensive use of isometric training. Although this does not deviate from S&C guidelines and research, it provides an area for further exploration. Coinciding with S&C coaches working in professional soccer in output [2], *"focusing on the basics"* was a key component of programs, and common issues orientated around congested scheduling, fixtures, and time constraints. Although this reiterates the results from output [2], it highlights and strengthens the implications of these findings in professional team sports. Output [3] concludes with practical and actionable recommendations for S&C coaches working in professional cricket.

Output [4] *Practices of strength and conditioning coaches in professional sports: A systematic review.*

As discussed within outputs [1-3] there are extensive guidelines and research regarding the general and sport-specific benefits of testing and training strength, power, speed, plyometric, and flexibility to develop athletes [39]. However, comparatively little is known about how S&C guidelines and research are used by S&C coaches in professional sports. For example, strength training is commonly periodized into S&C training programs to improve professional athletes' sports performance and resilience to injury [62]. But, given the difficulties in conducting research at the professional level and the scarcity of available data on topics such as periodization [62–64], researchers may use alternative means to explore and understand the use and efficacy of S&C training methods [62]. Consequently, there's a growing number of studies using surveys (inclusive of outputs 2-3) to investigate the practices of S&C coaches in professional sports [8–12,14,42]. These surveys have generally been adapted and developed from Ebben and Blackards' original work investigating S&C coaches in American football [8], providing a strong basis to compare findings across studies.

Therefore, output [4] systematically reviewed evidence from prior surveys investigating the practices of S&C coaches in different professional sports. This enabled the identification of common and differential practices applied across sports used to optimize the physical and sporting performance of players. Findings from output [4] were critically assessed against general and sport-specific guidelines and research in S&C. This led to comprehensive recommendations and suggestions being made for S&C coaches working in professional sports to develop various athletic abilities. These included the use of periodization strategies, compound exercises (e.g., squat and variations), speed exercises (e.g., sprinting), and plyometric exercises (e.g., multiple hops). It was also recommended that S&C coaches perform regular physical testing (e.g., pre-, in-, and post-season) to monitor each player's physical condition, with this data also used to inform the design and assess the efficacy of S&C training programs. Differences amongst sports were observed, suggesting S&C coaches may apply contrasting methods based on their preferences, popularity of practices, culture, or limitations of working in a professional sports environment. Consequently, output [4] also provides evidence-informed suggestions to improve S&C practices in certain sports. This study is unique, as it provides a one-stop reference for sourcing information on the practices of S&C coaches working in various professional sports.

Output [5] *Strength and conditioning practices and perspectives of volleyball coaches and players.*

Volleyball is a high-intensity anaerobic sport [65], that includes common movements such as spiking, blocking, and diving [66]. The most important physical attributes associated with superior match play performance are strength, power, and speed [67–69]. To develop these physical attributes, S&C coaches should design a progressively overloaded training program, comprising whole-body functional exercises [67]. However, S&C coaches must also accommodate different volleyball positions (e.g., physical and skill-based requirements) and individual player profiles (e.g., physical ability and injury history) [70,71]. Accordingly, significant relationships ($p \leq 0.05$) between players' physical ability and volleyball position game stats have been shown, including defensive specialists with squat and total strength; setters with hang cleans, T-drill, and broad jump; pin hitters with vertical jump, squat, and total strength; and middle blockers with broad jump [70].

Repetitive jumping, landing, hitting, and blocking actions are associated with an increased prevalence of injuries to the ankles, knees, lower back, and shoulders in volleyball players [72–74]. Therefore, injury reduction measures are required to ensure players are physically fit and available for selection [72,74]. Such methods include preventing unnecessary spikes in training load through monitoring and adjusting the volume and intensity, while also improving players' muscular strength and endurance [73,74]. For example, to reduce overuse injuries of the knees, S&C programs are recommended to use eccentric strength exercises to condition the thighs, hips, and core muscles to absorb landing forces from repetitive jumps [73,74]. It is clear the physical preparation of players for the demands of volleyball is important, however, there is very limited research on the physical training practices employed [75]. Again, similar to soccer in output [2] this is surprising given volleyball has over 500 million registered players globally and 222 member federations [76,77].

Through my personal experience of working with various NSAs in Hong Kong, it was prevalent that S&C coaches were infrequently employed to design and implement S&C programs, particularly at sub-elite levels. Consequently, sports coaches, players, and support staff are often tasked with this responsibility. Therefore, output [5] specifically targeted and surveyed volleyball coaches and players in Hong Kong concerning their S&C practices and perspectives. This provided primary evidence and added to the limited literature regarding S&C in regional (Hong Kong) and international volleyball.

The most pronounced finding from output [5] was that 75% of coaches and 53% of players reported that S&C coaches were not responsible for delivering S&C provisions and that S&C sessions were mostly conducted independently or by support staff. Furthermore, coaches and athletes exhibited a lack of education, qualifications, and accreditations in S&C. This was despite sports coaches and players specifying that S&C was *"important"* for the development of volleyball skills, physical, fitness, and injury parameters. Therefore, this raises concerns regarding the quality and safety of S&C being delivered, particularly when prescribing more advanced exercises or programs. Consequently, only 10-20% of respondents declared their S&C provisions were *"very effective"*. The reasons provided for a lack of S&C coaches being employed within Hong Kong volleyball were multifaceted, ranging from inadequate availability of S&C coaches to limited funding available. Therefore, raises an important request for NSAs and S&C governing bodies to provide additional support by making education

and accreditations more accessible to those delivering S&C (i.e., sports coaches and athletes).

The publication and dissemination of results from Output [5] have led to positively impacting S&C provisions for national volleyball players in Hong Kong, which is further discussed in Chapter 2.3. Whereas it is hoped this output will lead to further research and initiatives investigating and developing S&C provisions in volleyball across countries and levels.

Output [6] *Practices and perspectives of strength and conditioning in soccer coaches and players.*

In recent years there has been a growing interest and emphasis on the physical and physiological demands of soccer players [38]. As a high-intensity intermittent sport, possessing strong aerobic and anaerobic conditioning, speed, agility, power, and strength, are considered advantageous for soccer performance [38]. Furthermore, due to the competitiveness of match-play, injury incidences in competition are as high as 65.9/1000 hrs in adult professional soccer players [78]. To develop these attributes and reduce player injuries, S&C coaches are commonly employed.

However, as outlined in output [5], regionally in Hong Kong a high proportion of coaches and players are tasked with delivering their S&C provisions independently. Whether this is the case in other Hong Kong sports (i.e., soccer) is uncertain and warrants further investigation. This is important from a quality and safety standpoint, but as aforementioned to also ascertain whether those responsible for delivering S&C are employing practices that align with general and soccer-specific guidelines and research in S&C [38,40,78,79].

Therefore, output [6] investigated the S&C practices and perspectives of soccer coaches and players in Hong Kong. Collectively with output [5], this output adds to the limited evidence regarding S&C in Hong Kong sports and allows collective and meaningful conclusions to be made from our findings. Internationally this is the first evidence presented specifically addressing the S&C practices and perspectives of soccer coaches and players. Therefore, the wider soccer community (e.g., NSAs of other countries) can use the methods (i.e., survey instrument) and findings from this output to support the development of S&C provisions and services. Coinciding with output [5], coaches and players in Hong Kong soccer believed S&C to be *"very*

important" for various soccer, physical, fitness, and injury parameters. Also, responses regarding the S&C practices and perspectives employed mostly aligned with contemporary guidelines and research in S&C and soccer. Despite more than 60% of respondents in this study being responsible for delivering S&C independently, it was reassuring to see their willingness to undertake relevant education, but only if it became more accessible. Again, this is an important message for soccer and S&C governing bodies, to consider options for further support.

The impact of output [6], similar to output [5], has led to the development of S&C provisions for the Hong Kong Football Association (HKFA), which is further discussed in Chapter 2.3. Furthermore, results from this study provide needed data and information to further encourage the development of S&C education, practice, and research in soccer.

Output [7] *Practices of strength and conditioning coaches in Brazilian elite soccer*.

Brazil is a leading soccer nation, with over 22,000 players and 470 coaches registered with the Brazilian Football Confederation (CBF) [80]. Furthermore, is a huge exporter of soccer players to the world's leading leagues [81], with over 2,000 international transfers taking place in 2019, equating to over USD 370 million in negotiations [81–83]. These leading soccer leagues are characterized by their high and ever-increasing physical and physiological demands [84–86]. For example, across seven successive seasons of the English Premier League the distance covered through sprinting and high-intensity running increased by ~35% [84]. Consequently, these evolving physical, technical, and tactical demands in professional soccer pose significant challenges to soccer coaches and support staff, for the implementation of effective and time-efficient S&C practices [87–90]. However, there is limited evidence regarding the practices and perspectives of Brazilian soccer S&C coaches. These data are essential to comprehensively understand and enhance S&C practices in Brazilian soccer, and provide the wider soccer community insight to how Brazilian soccer players are trained and tested at Brazilian clubs.

Therefore, the original contribution of output [7] was to investigate the contemporary information on the practices and perspectives of a new region and population (i.e., Brazilian soccer S&C coaches). Furthermore, as output [7] adapted the survey used in output [2], this allowed critical reflection between outputs, enabling the

identification of common S&C practices in soccer, and those representing regional or cultural differences. Numerous similarities were presented between outputs [2, 7], which was expected given the likelihood of experienced S&C coaches employing evidence-informed practices. Differences were also apparent, such as in output [2] 100% of S&C coaches prescribed flexibility exercises compared to 73% in output [7]. The purported reasons for Brazilian S&C coaches using flexibility exercises less frequently were related to time and resource constraints. Furthermore, given the equivocal evidence that flexibility exercises improve performance and reduce injuries in professional soccer athletes, S&C sessions were focused on developing other attributes (e.g., speed and power). The modification of some questions also provided a deeper understanding of the practices of S&C coaches on certain topics. For example, in output [2] the question regarding periodization strategies was general "*do you use periodization strategies?*", whereas the question in output [7] was specific "*do you use a pre-programmed training plan with pre-programmed performance peaks?*". Results indicated that in output [2] 98% of S&C coaches used a periodized plan, whereas, in output [7] 6% of S&C coaches adopted pre-programed periodized plans and 94% used a flexible programing approach.

Collectively these findings provide greater insight into the practices of S&C coaches in professional soccer and can inform future guidelines and research. Furthermore, this information will specifically help S&C coaches and the wider soccer community working with professional Brazilian soccer players, to adapt training practices to their specific backgrounds and needs, while accelerating their integration and development in foreign leagues.

2.3 Evaluation of the contribution made by the portfolio of evidence to the subject area

All readership and citation data in this chapter has been sourced from ResearchGate and is accurate as of the 10th of May 2022. All self-citations as first author and co-author have been removed for transparency.

Output [1] *Practices of strength and conditioning coaches: A snapshot from different sports, countries, and expertise levels.*

Before publishing output [1], the majority of available information on the practices of S&C coaches derived from Ebben and colleagues' work in professional North American sports [8–11]. Accordingly, contextualizing the data from these studies for a global audience is somewhat difficult. Therefore, output [1] provides a broader perspective and primary evidence for S&C coaches working in different sports, countries, and levels. Furthermore, served as a strong basis (i.e., survey design) for all subsequent outputs within this portfolio. The findings from output [1] provide first-hand insight into the practices employed by S&C coaches, which are critically reviewed against contemporary guidelines and scientific evidence in S&C. Accordingly output [1] is valuable for informing practitioners, researchers, and students in S&C and associated areas, which is evident from being read over 473 times. Personally, findings from output [1] have been extensively integrated into my teaching materials and curricula, and similarly adopted by colleagues in higher education.

The dissemination of this output through various channels (e.g., social media, internal networks), led to insightful discussions with practitioners and researchers regarding the methods used and results obtained. Unlike prior research, this study was the first to publish the survey instrument used to collect responses from S&C coaches. Consequently, several researchers disclosed that they intend to use or adapt our survey as a basis to carry out their research. Furthermore, this output has led to my involvement as co-author on associated research papers, including 1) 'Coaches perspectives on the positional demands of South African schoolboy players during a competitive rugby match' which will be submitted to the journal of *Physical Education and Sports Pedagogy*, 2) 'Contemporary practices of strength and conditioning coaches in Australasian team sports' and 3) 'Practices and perspectives of judo S&C coaches, sports coaches, and athletes across countries and levels' which will both be submitted to the *Journal of Strength and Conditioning Research*. With the original objective of this output to broadly reach and engage those in the S&C industry, receiving co-author invitations from Africa, Australasia, and South America, demonstrates this has been achieved.

Output [2] *Contemporary practices of strength and conditioning coaches in professional soccer*.

This output has been read over 2,113 times and cited 8 times. Information from selected citations include:

1) ‘Mind the gap! A survey comparing current strength training methods used in men's versus women's first team and academy soccer’ published in *Science and Medicine in Football* by Mcquilliam et al (2022). This study revealed that practitioners responsible for delivering S&C (i.e., S&C coaches, fitness coaches, and sports scientists) in men’s first team professional soccer held similar academic qualifications to that reported in output [2]. For example, 21% of practitioners held a Ph.D., compared to 25% in output [2]. This finding reinforces key demographic information provided in output [2] and importantly highlights the education requirements for those pursuing a career in professional soccer.
2) ‘Resisted sprint training with partner towing improves explosive force and sprint performance in young soccer players- a pilot study’ published in *Biology of Sport* by Chaalali et al (2022). Here information was taken from output [2] to evidence the use of plyometric training to develop physical characteristics associated with superior soccer performance (e.g., speed). Understanding not only what practices are employed by S&C coaches in professional soccer (e.g., plyometrics) but also the reasons why (e.g., speed development) was a focus of output [2], which the application of our findings here represent.
3) ‘A systematic review of the criterion validity and reliability of technical and tactical field-based tests in soccer’ published in *Biology of Sport* by Clemente et al (2022). This study used our findings to demonstrate the importance and varied approach to physical and physiologically testing soccer players. This was an underpinning aim of output [2], to present primary evidence on the practices of S&C coaches in professional soccer (e.g., type and frequency of testing approaches).
4) ‘Effects of small-sided games on oxygen consumption, agility, and focused attention in football’ published in *Revista Brasileira de Fisiologia do Exercício* by Silva et al (2021). Here our results were broadly used to infer the importance of integrated sports conditioning sessions. For example, accompanying physical conditioning with other elements of soccer gameplay (e.g., technical, tactical). This was a novel finding from output [2], that S&C coaches commonly possessed soccer coaching qualifications, enabling the design and

implementation of training programs that include sport-specific movements and decision-making processes.

5) 'Effects of plyometric jump training on soccer player's balance: A systematic review and meta-analysis of randomized-controlled trials' published in *Biology of Sport* by Clemente et al (2021). This study used our findings to highlight the different plyometric training strategies (e.g., time and type) employed in soccer and to raise discussion about what constitutes best practice. This demonstrates that output [2] has provided a valuable contribution to the literature, by providing needed data on the methods employed for various S&C practices, including plyometrics.

Output [2] was distributed amongst S&C practitioners and researchers in soccer, which led to positive interest and discussion regarding contemporary and future S&C practices. Consequently, I have since been invited to co-author five soccer-related papers, being 1) 'Quantification, tapering and positional analysis of across 9-weekly microcycles in a professional Chinese Super League soccer team' published in *EC Orthopaedics* by Owen et al (2020), 2) 'A comparison of match demands using ball-in-play versus whole match data in professional soccer players of the English Championship' published in *SPORTS* by Mernagh et al (2021), 3) 'Off-training physical activity and training responses as a determinant of sleep quality in young football players' published in *Scientific Reports* by Mateus et al (2021), 4) 'Analysis of the most demanding passages of play in elite youth soccer: a comparison between congested and non-congested fixture schedules' submitted to *Science and Medicine in Football* by Jiminez et al (2022), and 5) 'Can complex training interventions improve maximal leg strength, repeated sprint ability, and endurance in soccer players? A systematic review and meta-analysis' submitted to *Human Movement* by Thapa et al (2022).

Output [2] also provided a basis for discussions with the HKFA and Brazilian researchers, regarding the development and practices of S&C in soccer. These discussions led to the conception of outputs [6-7], which are discussed below. Findings from output [2] have been extensively integrated into my undergraduate module 'S&C for sports performance'. Here students are required to conduct a needs analysis and develop an S&C program for a team sport, one of which is soccer. Output [2] provides

students with extensive information that can be used to underpin or question the implementation of various S&C methods.

Output [3] *Contemporary practices of strength and conditioning coaches in professional cricket.*

Output [3] has been read 148 times and cited 1 time. Information from the citation includes:

1) 'Optimising long-term athletic development: An investigation of practitioners' knowledge, adherence, practices and challenges' published in *PLoS One* by Till et al (2022). This study used our research to demonstrate the uptake of survey-based methods to address contemporary topics in sport. This is important as it reinforces the standing of alternative research methods (i.e., surveys) to broadly reach desired populations.

The S&C practices and perspectives presented in output [3] derive from various countries and leagues underrepresented in the literature. Personally, this study has been useful given my roles with CHK, including lead of sports performance and workplace supervisor for students undertaking S&C internships. Accordingly, results from this output have directly informed my practice and how I teach and advise interns to develop cricket-specific S&C programs. For example, it was revealed the widespread use of isometric exercise in cricket, which made me critically reflect on my programing, leading to the further inclusion of this mode of exercise. This was coupled with an intern deciding to undertake her undergraduate thesis, looking at 'The effects of upper body post-activation potentiation on throwing velocity in national male cricket players' which investigated the relationship of isometric contractions on subsequent throwing velocity. This has been accessed over 713 times on ResearchGate. Data from outputs [2-3] were pooled to develop a conference presentation titled 'Current issues, desired changes, and future trends: opinions of S&C coaches in professional soccer and cricket' for the ASCA Annual Conference 2020. The presentation received positive feedback and I was awarded the ASCA junior research award.

Hereafter, I conducted further research in cricket, where I led one paper titled 'Physical profiling of national cricket players: an investigation between bowlers and batters' published in *Biology of Sports* (2020) and co-authored 'Seasonal variation of

physical performance and inter-limb asymmetry in professional cricket athletes' published in the *Journal of Strength and Conditioning Research* by Bishop et al (2020). Collectively, these two studies provide much-needed normative data on professional cricketers, that S&C coaches, support staff, and researchers can use as reference. Furthermore, I am currently leading a series of papers advising the practical application of S&C for cricket batters, fielders, wicket-keepers, and all-rounders, with leading researchers and practitioners in cricket, that will be submitted to the *Strength and Conditioning Journal.* This ongoing research in cricket has led to my invitation to be part of a roundtable discussion titled 'Cricket performance, testing and training' at the 2022 Cricket Research & Practice Conference at the University of the Witwatersrand, Johannesburg, South Africa.

Output [4] *Practices of strength and conditioning coaches in professional sports: A systematic review.*

Output [4] has been read over 2398 times, which demonstrates strong interest given the short space of time this study has been published. These readership figures are likely due to the growing interest and importance of S&C in professional sports, and this is the first study to conclude prior research on the practices of S&C coaches. Within this systematic review, outputs [2-3] were included as reviewed studies, building a strong link between outputs in this portfolio. Dr. Irineu Loturco was invited to co-author this output, which in conjunction with output [2], underpinned output [7]. Due to the comprehensive nature of output [4] and its inclusion of several papers already integrated into my teaching materials, it has become a core study for my undergraduate students to read, to understand S&C from a practitioner's perspective.

Output [5] *Strength and conditioning practices and perspectives of volleyball coaches and players.*

This output has been read over 1243 times and cited 2 times. Information from the citations include:

1) 'The Effect of High Intensity Interval Training on Agility Performance' published in the *Pakistan Journal of Medical and Health Sciences* by Ön (2021). This paper used our findings to justify the manipulation of training intensity and

mode to elicit the desired effects for muscular strength and endurance in volleyball players. As aforementioned, given the limited evidence of S&C practices in volleyball, it is reassuring to see that our study is providing a basis for general and sport-specific assumptions to be made.

2) 'The Running Athlete: A Comprehensive Overview of Running in Different Sports' is a published book by Springer and authored by Canata et al (2022). The information taken from our paper was to evidence the limited prescription of running-based activity within volleyball, with a greater focus placed on other forms of S&C (e.g., plyometrics). The authors agreed with our finding as volleyball requires short-intermittent explosive actions as opposed to continuous running actions.

With the support of the Hong Kong Volleyball Association (HKVBA), output [5] was undertaken to provide general and region-specific data and guidance for S&C in volleyball. Findings from output [5] uncovered that although S&C was deemed *"important"*, it was predominantly delivered by sports coaches, players, and support staff, who lacked relevant qualifications and experience. These findings were well received by HKVBA and highlighted the need to improve the quality of S&C provisions. This led to a memorandum of understanding being signed between my institute (THEi) and the HKVBA to develop a high-performance training program, with S&C and sports therapy support for national representative volleyball players. A strong focus of this collaboration was placed on it being student-centered, which provided my students the opportunity to obtain industry experience and include national volleyball players as subjects for their undergraduate research projects. Furthermore, this collaboration has led to pilot research being conducted on the benefits of wearable resistance as a training method for improving volleyball skill performance. Finally, as with prior outputs [1-3], the survey instrument used in this study was published, which has been used as a template for three undergraduate student dissertations, investigating rugby union, field hockey, and basketball in Hong Kong.

Output [6] *Practices and perspectives of strength and conditioning in soccer coaches and players.*

Output [6] has been read over 943 times. This output was supported by the HKFA, to provide general and region-specific evidence and advice for S&C in soccer. The findings from output [6] demonstrated that although a greater number of qualified S&C coaches were employed to deliver S&C provisions in soccer compared to volleyball in output [5], these were still mostly delivered independently by athletes and coaches. Therefore, it was similarly concluded the need for an improved S&C infrastructure and additional support from the HKFA and affiliated clubs. Consequently, this output prompted constructive meetings with the HKFA and led to a memorandum of understanding being signed with my institute (THEi). This collaboration quickly led to the development of S&C and sports therapy provisions for the HKFA futsal team, in preparation for upcoming international fixtures and tournaments. Once again, this orientated around students obtaining valuable industry experience under the supervision of qualified staff, while collaborative student research projects are being discussed.

With the contributions made from outputs [5-6], and the student research projects completed in Hong Kong rugby union, field hockey, and basketball, I am currently collating this evidence to produce a regional review of the 'Strength and conditioning practices and perspectives of Hong Kong team sports coaches and players'. Furthermore, on the back of this output, Prof. Michael Duncan who has co-authored several outputs in this portfolio invited me to co-lead a study investigating the 'Practices and perceptions of fundamental movement skills in grassroots soccer coaches' which was published in the *International Journal of Sports Science and Coaching* (2022). Prof. Duncan and I, are now expanding the aforementioned study internationally, to obtain a more robust understanding concerning the application of fundamental movement skills in soccer. New and prospective research broadening into different areas of physical development (e.g., fundamental movement skills), demonstrates the important contribution and provisional evidence provided by outputs [5-6].

Output [7] *Practices of strength and conditioning coaches in Brazilian elite soccer.*

Output [7] has been read over 1092 times and cited 1 time. Information from the citation includes:

1) ‘Comparison analysis between playing positions in the 30-15 IFT test in male professional soccer players’ published in *Revista Educación Física Chile* by Pérez-Contreras et al (2021). Information was used from our paper to explain that practitioners in professional soccer use different physical tests (e.g., aerobic capacity, strength, speed, power, agility) during different phases of the season. Before our publication, the application of such practices was assumptive, whereas now fellow researchers can access published data regarding their use and prevalence in Brazilian soccer.

Output [7] was predominantly underpinned by output [2], but to some extent by all outputs within this portfolio. Dr. Irineu Loturco lead author of output [7], read output [2] and contacted me to discuss how our findings compared to those employed by S&C coaches working in professional Brazilian soccer. It was subjectively hypothesized that there would be disparities between Brazil and other soccer nations due to cultural and logistical differences. Consequently, output [7] became the first paper to address the practices of S&C coaches in elite Brazilian soccer. The undertaking of output [7], demonstrates the contribution of prior outputs and the gradual impact they are having, as it is prompting researchers to investigate underrepresented populations and adapt our published methods (i.e., survey instruments).

Output [7] provided interesting findings from professional Brazilian soccer that may be of interest to other countries and leagues. For example, S&C coaches highlighted issues, such as extensive traveling, inadequate recovery time, and the importance of sleep, which are comprehensively discussed with relevant literature and actionable recommendations given. This output also led to a follow-up collaboration with Dr. Loturco, investigating the ‘Strength and conditioning practices of Brazilian Olympic sprint and jump coaches’ published in the *Journal of Human Kinetics* (2022).

This chapter demonstrates that although the outputs forming this portfolio have only been published for a short period, they have received positive interest and are collectively making an impact. In education, I and my colleagues have been able to design contemporary learning and teaching materials in S&C and related topics for our undergraduate degree program based on the primary evidence presented within each output. From a research perspective, the dissemination of findings has prompted discussions with fellow researchers, often leading to co-authorship opportunities on

associated papers. In particular outputs [5-6] have informed relevant stakeholders and organizations regionally in Hong Kong. Consequently, this has led to positive changes regarding the S&C provisions provided by NSAs. For example, my institute (THEi) has collaborated with the HKVBA and HKFA to develop high-performance training programs, including sports therapy and S&C support. These collaborations create a strong foundation for impacting the current understanding of S&C and practices employed within Hong Kong sport. Furthermore, will help identify where additional support in the form of education or continued professional development is required.

2.4 Contribution of co-authors to the outputs of research

The implementation of quality S&C provisions requires a collaborative effort from S&C coaches, sports coaches, athletes, and support staff. Working as a team creates opportunities to raise problems, share opinions, and find solutions. This can create greater alignment between departments to reach the overarching goals of improving athletes' physical and sporting performance while reducing injury occurrence. A similar multidisciplinary approach was taken for the outputs within this portfolio, whereby co-authors were recruited based on their experience as researchers, practitioners, or athletes in relevant sports. Also, as different outputs were conducted in specific countries (i.e., Hong Kong and Brazil) and internationally (i.e., across different countries), it was deemed important to work with co-authors who could provide regional and global perspectives.

I was the first author in outputs [1-6] and led the conceptualization, study design, data collection, data analysis, writing up, and submission of each paper. I assembled and directed each research team, which was tailored to meet the specific needs and topic of each paper. For output [7], my initial involvement was discussing the surveys and findings from prior outputs [1-6], and how these could be adapted to Brazilian soccer. After data collection, I provided comprehensive feedback and amendments to the draft paper, particularly regarding the presentation of results. Finally, I comprehensively reviewed the paper and suggested further improvements before submission.

Prof. Michael Duncan was responsible for overseeing outputs [1-6] and provided guidance from conceptualization to submission. He patiently discussed his experience

in role delegation, project management, paper submission, and the review process with me. This was especially important when submitting the initial outputs of this portfolio. Furthermore, he played a key role in the design of each survey, and the write-up and revision of each paper.

Assoc. Prof. Anthony Turner was central to designing the surveys used for outputs [1-3], where he provided valuable insight from an S&C researcher and practitioner perspective. Furthermore, to help outputs [1-3] reach the relevant participants, he made use of his extensive network in S&C. For output [4] he guided the development of the systematic review and shared ideas on how to best present the results. For all outputs [1-4], he made constructive and valuable contributions during the submission and review process.

Dr. David LaPlaca had previously conducted survey-based research addressing the characteristics of different levels of S&C coaches in North America and Australia. Therefore, for output [1] he advised how to reach the targeted population (S&C coaches) and structure our survey, to ensure each question was presented appropriately. Furthermore, given his extensive connections in North America, he was crucial in distributing the survey within this region. He also reviewed output [1] several times, providing recommended changes before initial submission and during the review process.

Prof. Jaime Sampaio assisted with the survey design, distribution, and write-up of output [1]. For output [2], he primarily advised on the modifications of the survey to address S&C coaches in soccer and provided important changes and recommendations for the final version submitted. For both outputs, he discussed with me how to present data concisely in a reader-friendly format.

Assoc. Prof. Candice Christie was integral to the conception of outputs [1, 3]. She had previously conducted similar research, therefore provided valuable experience and guidance on survey design and distribution, and data presentation. Furthermore, given her reputation and network in S&C and cricket in South Africa, she was integral to reaching this demographic for each survey. She also provided important

recommendations for writing and structural improvements for each output and provided valuable guidance during the review process.

Dr. Irineu Loturco was invited to co-author output [4], given his extensive research and practical experience in S&C. He provided advice on how to interpret the results from the systematic review generally and specifically for each sport. Hereafter, we discussed conducting a paper to investigate the practices of S&C coaches in professional Brazilian soccer, which eventually formed output [7]. This also served the purpose of building upon outputs [2, 6], which looked at S&C practices in soccer across different countries and specifically in Hong Kong. For output [7], Dr. Loturco adapted the surveys used in outputs [1-3] and led the data collection, analysis, and write-up.

Assoc. Prof. Neil Clarke and Dr. Chris Bishop helped with the design of the two surveys used to investigate the S&C practices and perspectives of volleyball and soccer coaches and athletes in outputs [5-6]. Furthermore, Dr. Clarke and Dr. Bishop extensively advised on the format and content of each output and contributed well throughout the review process.

Prof. Del Wong and Dr. Mark Noon were invited to co-author output [2], whereas Dr. Adam Owen and Mr. Nuno Mateus were invited to co-author output [6]. These co-authors were approached given their extensive research and experience in soccer. They all provided invaluable recommendations for writing structure, literature support, and content for each output. Moreover, proposed suitable revisions before submission and during the review process.

Asst. Prof. Robert Lockie co-authored output [4] and provided a vast amount of knowledge and experience in S&C. Given this was the first systematic review I have completed he provided useful advice on how to structure the paper and report the most significant findings. He also made extensive comments on how to improve the paper before initial submission and during the peer-review process.

Ms. Vivian Lai and Ms. Cecilia Pang were integral to the collection of contact information for S&C coaches in outputs [2-3]. Furthermore, made useful sport-specific contributions during the write-up process, given their backgrounds in soccer and cricket

respectively. This made each paper read more clearly and allowed for meaningful practical applications to be made for each sport.

Mr. Sing Wong is a graduate of THEi, who also completed a master's degree in S&C at Middlesex University (England) and obtained NSCA CSCS status. He is now employed at THEi as a physical education officer. Given the population reached for outputs [5-6] being from Hong Kong, all information relating to the study (e.g., survey) was presented in Cantonese and English, which Sing handled. Furthermore, some responses were received in Cantonese, therefore Sing translated these back into English before analysis. He also reviewed each output once written and made useful recommended changes.

Mr. Jason Mak and Mr. Matt Pears, are representatives of the HKVBA and HKFA, respectively. Both co-authors were imperative to the design and distribution of surveys for outputs [5-6]. They provided local and sport-specific guidance, which led to a smooth data collection and analysis process. Both contributed well to the final paper, particularly from a volleyball and soccer perspective.

Chapter 3: Critical reflection on development as a research practitioner, conclusions, and suggestions for further work

3.1 Critical reflection on development as a research practitioner

My first research publication was in 2014, as a co-author on a project led by Prof. Michael Duncan, titled 'The effects of sodium bicarbonate ingestion on back squat and bench press exercise to failure' published in the *Journal of Strength and Conditioning Research*. This opportunity allowed me to develop my research practice, through being involved in the design, conduction, evaluation, and publication of research [91]. My major responsibilities were to lead data collection, which made me appreciate the need for a structured approach when tackling a research question, and how well-designed research methods underpin the quality of a research project. Although my initial thoughts of co-authoring were to distribute workload, it became apparent my role was multifaceted as I was also expected to co-construct knowledge and ideas [91]. For example, I had to critically think and share my views on how findings from this study could be interpreted and used by S&C coaches. Accordingly, I became aware of key terms such as evidence-informed practice and ecological validity (i.e., the generalization of research findings to real-world settings) [92]. This is where my concept of reverse engineering research originated, where I would use my practice or observations of others, to propose research ideas and topics.

After this initial research experience, I applied for various research and Ph.D. positions but was unsuccessful. Therefore, opted to develop my professional practice in education, sports coaching, and S&C. This enabled me to obtain broader experiences within these disciplines, which also informed my future research. In 2015, I gained employment in Hong Kong as a lecturer at THEi, where I aimed to re-ignite my research interests. Here, I was initially mentored by Prof. Del Wong, a leading researcher in soccer and S&C, but he left the institute shortly after my appointment. Therefore, although I had the desire to conduct research, departmentally there wasn't a strong research base. This was a challenging time, as I was aware of the important role mentorship plays in the development of a researcher (e.g., productivity, self-efficacy) [93]. Consequently, I reached out and developed a supportive network of international researchers in sports science and S&C, such as Assoc. Prof. Anthony Turner of the

United Kingdom, Prof. Jaime Sampaio of Portugal, Assoc. Prof. Candice Christie of South Africa, and Dr. Irineu Loturco of Brazil, amongst others.

Through discussions with my research network, I was advised to use my experience and current roles in higher education and S&C to inform my research. This would also enable the critical application of research findings, thus bridging research with practice. For example, through extensively reviewing S&C literature in cricket for my current role as lead of sports performance with CHK, there was a need for further information on the practices and perspectives of S&C coaches working in professional cricket, which output [3] provided. From this study, I adopted certain findings into my practice (e.g., the use of isometric exercises) and disseminated findings to students who I supervise through their undergraduate research projects and internships with CHK. To measure the impact and holistic development of these students during their internships with CHK, I also investigated 'The effects of work-integrated learning on undergraduate sports coaching students' perceived self-efficacy' published in the *International Journal of Work Integrated Learning* (2019). This demonstrates a multi-dimensional approach to my research, where I not only aim to contribute new knowledge, but also ascertain whether this knowledge has informed professional skills applied in the field [94].

Collaborating with international leaders in my field has been a comprehensive and supportive learning curve in undertaking research. Accordingly, leading and co-authoring research papers is considered a key pedagogical research practice [95]. Furthermore, the collaboration of researchers from countries less developed in discipline-specific fields with those more established (e.g., S&C in Hong Kong vs. the United Kingdom) [96], can further enhance the quantity, quality, and impact of publications [97,98]. However, considerable time and effort have also been spent independently developing my research ability. This has mostly been improved through the 'act of doing' and reflecting on the lessons learned throughout the research process to inform future decisions [99]. Examples are provided below.

When publishing a paper, an area I found particularly arduous and confusing was the formatting and submission regulations of different journals. To which minor mistakes were made during the review process of outputs [1-2]. This was frustrating, but an important part of the learning process, whereby I explored alternative methods to overcome these problems. For example, I previously used manual referencing, which was time-consuming and prone to errors (i.e., when re-writing sections of a paper or

changing reference styles). Therefore, I adopted automated referencing software Zotero, which helped overcome both issues. Another area I initially found difficult was the peer-review process, particularly when replying to some reviewers' comments, and modifying a paper accordingly. Through concurrently co-authoring other papers and going through the review process with experienced researchers, provided me with the experience and a clearer understanding of how to respond effectively. Which included how to clarify whether comments had been accepted, debated, or rejected.

Collectively, these experiences have developed my ability as a research practitioner, from the conception of an idea to the dissemination of findings. Furthermore, has evolved my practice of reflection from a formal process to reflection-in-action, where I can think proactively and make effective research decisions [94]. The following outlines, the process of publishing outputs [1-7] within this critical review.

Output [1] was published in the *Journal of Strength and Conditioning Research*, which is the most reputable and highest impact journal specifically in S&C. At the time I was relatively inexperienced at leading an author team, therefore, I was appreciative of the co-authors supporting me through this process. However, guidance on how to best manage the research project was sometimes contrasting, such as for role delegation. Some co-authors recommended I take the lead and ask for support and guidance when required, whereas others suggested distributing the workload. I opted for the latter and gave each co-author tasks during the initial write-up and review stages (e.g., to write a certain section). However, when I received the work back from each co-author, it was incredibly difficult to amalgamate the different views and writing styles into one coherent paper. Therefore, it took a long time to re-write and format the paper. Although this made me value the importance of drawing upon the knowledge and expertise of each member of my research team, it made me adopt an alternate approach for writing future outputs. Hereafter, I frequently requested comprehensive input from co-authors but used tracked changes or comments, as opposed to directly modifying the paper. Therefore, I could easily accept or reject the required changes and write the paper consistently in my own words. This output went through two rounds of peer-review before publication, and as the methods used in this output underpinned those of subsequent outputs, it was pleasing to receive reviewer comments such as "*the questions asked in the survey are highly relevant to gain a deep understanding of*

current S&C practices" and "*the methodology is strong, which included several rounds of pilot testing*".

In Output [2], I included three of the same authors from output [1], Prof. Michael Duncan, Assoc. Prof. Anthony Turner, and Prof. Jaime Sampaio. This was based on the experience gained from the previous output, but also their knowledge of soccer. Furthermore, Prof. Del Wong, Dr. Mark Noon, and Ms. Vivian Lai were added to the research team, as they have extensive experience as researchers and practitioners in soccer and S&C. The wealth of knowledge and insight collectively between co-authors was instrumental in the design, modification, and distribution of the survey used in output [2]. Although only minor revisions were required after the peer-review process, these changes certainly improved the readability of the paper. Furthermore, I gained a lot of confidence as a researcher from the reviewer's positive comments, for example, "*the authors should be commended on a well-written paper that adds a great deal of knowledge to S&C, not only for soccer trainers but also for those involved with other intermittent sports with similar movement demands*".

In Output [3], I invited Prof. Michael Duncan and Assoc. Prof. Anthony Turner to co-author this paper, given their insight from previous outputs [1-2]. Furthermore, Assoc. Prof. Candice Christie and Ms. Cecilia Pang were added, given their research and practical experience in cricket. I was grateful for a very thorough peer review, which was a challenging and thought-provoking process to meet all requested changes. Here my co-authors provided valuable guidance as I found it difficult on occasions to articulate responses to certain reviewer comments. A rewarding outcome for this paper was it being commended from a research perspective and for the applicability of findings for S&C coaches working as part of multidisciplinary teams in cricket. For example, "*I think the study and caliber of engagement with S&C coaches working in professional cricket are impressive and provide a real sense of where the profession is and how it connects and engages with players and technical coaches*".

Output [4] was based on the work and findings from outputs [2-3], which used a similar survey instrument to prior research on the practices and perspectives of S&C coaches in professional sports [8–12,14], thus allowing a comprehensive systematic review to be conducted. Given this was my first systematic review, accessing the knowledge and

experience of co-authors was essential. Prof. Michael Duncan and Assoc. Prof. Anthony Turner were included given their contributions and understanding of the topic area from outputs [1-3]. Whereas Asst. Prof. Robert Lockie and Dr. Irineu Loturco were invited to provide fresh perspectives and different cultural views. This output required only minor changes after the peer-review process. Given the applied focus of the outputs within this portfolio, it was pleasing to receive the following comments from reviewers "*the practical aspects of the paper contribute positively to the link between science and practice, an area often overlooked*".

Output [5] derived from my practical work and experience as an S&C coach in Hong Kong. Here it was important to develop a research team with relevant experience to the topic area. Therefore, Prof. Michael Duncan, Assoc. Prof. Neil Clarke, and Dr. Chris Bishop were included given their extensive research backgrounds in S&C and sports science, and Mr. Jason Mak and Mr. Sing Wong who are reputable coaches and players in Hong Kong volleyball. Each co-author provided valuable input to the paper, particularly while designing the methodology (i.e., survey instrument) as this was fundamental to obtaining quality and relevant information from participants. Consequently, this led to a smooth data collection process aiding the write-up of results and discussion sections of the paper. Reviewers were complimentary of the "*novel*" and "*interesting*" nature of this output and provided worthwhile suggestions and improvements, which were adequately met and enhanced the paper.

Output [6] was constructed similarly to output [5], including four of the same co-authors, while adding experts in Hong Kong soccer Mr. Matt Pears, and experienced sports science and soccer researchers Dr. Adam Owen and Mr. Nuno Mateus. As with output [5], having input from the viewpoints of soccer researchers and those knowledgeable in Hong Kong soccer, was invaluable. The survey used in output [5] was adapted to meet the demands of Hong Kong soccer, where regional information and guidance were provided by Mr. Matt Pears and Mr. Sing Wong. After the data collection and completion of the first draft, all co-authors provided constructive comments and recommendations on how to best present the comprehensive quantitative and qualitative results derived from the survey. This led to reducing the results section which was initially too long. Output [6] was critiqued by co-authors for a few rounds before being submitted for review. Given output [6] led to the needed development of

S&C provisions for HKFA, it was pleasing to see a comment from one reviewer that "*the information from this study is especially relevant for coaches working in minor soccer leagues, where professionals commonly deal with limited facilities and resources to implement appropriate and effective S&C training practices*".

Output [7] stemmed from outputs [2, 4], and discussions held with Dr. Irineu Loturco regarding the lack of data available on the practices and perspectives of S&C coaches in Brazilian sport. Therefore, Dr. Loturco led this investigation into the 'Practices of strength and conditioning coaches in Brazilian elite soccer'. After data collection, I and other authors had some contrasting views on the results presented, which were possibly due to cultural differences, but also our preferences for S&C practices and training philosophies. This was importantly touched upon in the discussion, where contrasting findings from output [2] and other associated literature, were critically reviewed. It was a gratifying experience for me to go from lead author to co-author in output [7], where I was able to extensively advise and contribute to the methods (i.e., survey design), data collection, write-up, and publication of this type of research. Dr. Loturco was appreciative of my support and insight, which subsequently led to my inclusion in a follow-up paper titled 'Strength and conditioning practices of Brazilian Olympic sprint and jump coaches' in the *Journal of Human Kinetics* (2022).

3.2 Conclusions and suggestions for further work

The development of this portfolio originates from my experience as a sports coach, higher education lecturer, and S&C coach/consultant, which is extensively discussed in Chapter 1.1. Whereas the original contribution of outputs forming this portfolio is conceptualized by the need for a broader understanding of the background information, practices, and perspectives of S&C practitioners. This research provides necessary feedback and feedforward for the practical application and development of existing guidelines and literature in this field. Personally, my growth and progression from a research perspective, including the development of research methods, publishing papers, and working within and leading a collaborative team, have been reflected upon.

This portfolio demonstrates the achievement of the outlined objectives (Table 1), with the contribution of each output sufficiently investigating S&C practices and perspectives in various sports, countries, and levels. Findings have been

comprehensively and critically discussed with relevant governing body guidelines, literature, and research in S&C. From this, it is possible to identify and advise future areas of study in this field. This portfolio is incrementally making a positive impact on S&C practices, infrastructures, and research, regionally (Hong Kong) and internationally. An overview of the contributions made by each output toward the objectives of this portfolio is presented in Table 1. Thereafter each objective and the contribution of outputs are discussed in more depth.

Objectives

1. To identify contemporary S&C practices used in various sports and determine whether these align with S&C guidelines and research.
2. To investigate literature and research regarding S&C practices and perspectives, and the influence of sport, country, and level.
3. To highlight research gaps and critique the impact this has on the development of S&C.
4. To conclude the impact and implications of the research examined and outputs conducted, and propose further areas of research.

Table 1. Contribution of each output and the critical review in achieving the outlined objectives.

Output	Objective 1	Objective 2	Objective 3	Objective 4
1				
2				
3				
4				
5				
6				
7				
Critical Review				

Note: the depth of color represents the extent of contribution towards achieving each objective.

Objective [1] was achieved and contributed to by all outputs, which was most prevalent in outputs [1, 4] given these studies investigated and critically evaluated S&C practices across a range of sports. Although outputs [2-3, 5-7] looked at specific team sports (i.e., soccer, cricket, and volleyball) they also addressed whether the observed practices were consistent with recommendations from S&C literature and governing bodies.

Collectively, all outputs helped achieve objective [2]. Similar to above, outputs [1, 4] most broadly tackled this objective, given these studies investigated various sports, countries, and levels. Outputs [2, 6-7], comprehensively reviewed literature in soccer, and S&C practices were critically reviewed regionally in Hong Kong in outputs [5-6], Brazil in output [7], and internationally in output [2]. The target populations and results presented in outputs [1, 5-6] varied across levels from recreational to professional, and outputs [2-4, 7] solely in professional sport. To show the broad reach of this portfolio, survey responses were received from 523 S&C coaches, 72 sports coaches, and 60 athletes, across 30 countries, inclusive of all levels of sport.

All outputs contributed towards achieving objective [3], but none more so than the systematic review forming output [4]. This is because the inclusion criteria for this output required an exhaustive search of literature regarding the practices of S&C coaches specifically in professional sports. While other outputs in this portfolio collectively reviewed available literature for a range of sports, countries, and levels. Through this process, literature gaps were observed and critically discussed, thus concurrently justifying the need for each output and further research in this topic area.

Finally, objective [4] was met and contributed to by all outputs, but the main contributor was the critical review itself. This was largely achieved in Chapter 2.3, where each output was reviewed based on the contributions made to the subject field. This showed the importance of each output and why the evidence and data were needed for those responsible for delivering S&C. For example, developing and existing practitioners could establish whether their practices and views align with others in the field, or if they need to critically evaluate what they do. Furthermore, Chapter 2.1 brings together the link and collective impact of studies in this portfolio. This highlighted that S&C practices and perspectives generally crossover from sport to sport, but also demonstrate the importance of developing and applying sport-specific knowledge to optimize athletic performance and reduce injury occurrence. Further research stemming from this portfolio is outlined below.

A limitation of the current body of work could be targeted at the extensive use of survey techniques and simplistic data analysis methods (i.e., frequency and thematic analysis). It is acknowledged that other methods such as semi-structured interviews and focus groups could have been used to provide richer data and deeper discussion on emerging topics or issues. Also, that additional statistical methods such as analysis of variance [100] and chi-square [42] can be implemented to provide further analysis (e.g., identify between-group differences) of quantitative and qualitative data, respectively. However, the data collection and analysis methods used within this portfolio followed the foundational work published in this field [8–12,14] and surveys were deemed the most appropriate technique to obtain as large a sample size as possible, an important first step to broadly understanding the S&C practices and perspectives of coaches and athletes for specific sports, countries, and/or levels. Key areas have arisen from this portfolio that requires further investigation (e.g., the future of S&C and integration of technology), which would benefit from using the aforementioned methods (i.e., semi-structured interviews and focus groups). Yet, without the foundational work undertaken and extensive findings presented by this portfolio using survey-based methods, key aspects warranting further examination would not have been identified. To evidence my ability in using a broader range of research designs and techniques, my supplementary outputs are listed below, most of which were conducted concomitantly with this Ph.D.

The process of critically reflecting on my outputs included in this portfolio and extensively reviewing associated literature highlights the need for future research in this field. Here the survey instruments published in outputs [1-3, 5-6], can be used or adapted to further explore S&C practices and perspectives of underrepresented sports and populations. Accordingly, I have proposed, started, and completed research projects investigating other sports (e.g., judo), levels of sport (e.g., Olympic coaches), and populations (e.g., Africa and Australasia), while also evolving into associated areas (e.g., fundamental movement skills). This will provide a broader foundation of evidence that can be critiqued against existing literature to further evaluate similarities, differences, and challenges, across the S&C sector. Common practices will help underpin the foundations of S&C and demonstrate the broad applicability of certain methods across sports, levels, and countries. Whereas unique or anecdotal evidence, may provide rare insight into methods that are potentially one step ahead of guidelines and research, therefore in this instance, practices and perspectives may drive change.

Such data, as highlighted across all outputs will provide valuable insight for NSAs and governing bodies, to further support and develop current S&C provisions.

Supplementary outputs

1. **Weldon, A**., Owen, A. L., Loturco, I., Kyriacou, Y., Wong, W., Malone, S., Sampaio, J. & Scanlan, A. T. Match demands of male and female international lacrosse players competing under the World Lacrosse Sixes format. *Journal of Strength and Conditioning Research.* In press (2022).
2. Loturco, I., Haugen, T., Freitas, T. T., Bishop, C., Moura, T. B. M. A., Mercer, V. P., Alcaraz, P. E., Pereira, L. A. & **Weldon, A**. Strength and conditioning practices of Brazilian Olympic sprint and jump coaches. *Journal of Human Kinetics.* In press (2022).
3. Duncan, M. J., **Weldon A**., Barnett, L. M. & Lander, N. Practices and perceptions of fundamental movement skills in grassroots football coaches. *International Journal of Sports Science and Coaching*. Published online ahead of print (2022) doi.org/10.1177/17479541211073547.
4. Mateus, N., Gonçalves, B., Felipe, J. L., Sánchez-Sánchez, J., Garcia-Unanue, J., **Weldon, A**. & Sampaio, J. In-season training responses and perceived wellbeing and recovery status in professional football players. *PLoS One* (2021) doi.org/10.1371/journal.pone.0254655.
5. **Weldon, A**., Ma, W. W. K., Ho, I. M. K. & Li, E. (2021). Online learning during a global pandemic: perceived benefits and issues in higher education. *Knowledge Management & E-Learning*. **13**, 161–181 (2021).
6. Mernagh, D., **Weldon, A**., Wass, J., Phillips, J., Parmar, N., Waldron, M. & Turner, A. N. A comparison of match demands using ball-in-play versus whole match data in professional soccer players of the English Championship. *SPORTS* (2021) doi.org/10.3390/sports9060076.
7. Ho, I. M. K., Cheong, K. Y. & **Weldon, A**. Predicting student satisfaction scores of emergency remote learning in higher education during COVID-19 using machine learning techniques. *PLoS One* (2021) doi.org/10.1371/journal.pone.0249423.
8. Mateus, N., Exel, J., Gonçalves, B., **Weldon, A.** & Sampaio, J. Off-training physical activity and training responses as determinants of sleep quality in young football players. *Scientific Reports* (2021) doi.org/10.1038/s41598-021-89693-4.
9. Vernau, J. W., Bishop, C., Chavda, S., **Weldon, A**., Maloney, S. J., Pacey, R. & Turner, A. An analysis of job description and person specifications to define the

requirements for obtaining employment within strength & conditioning. *Professional Strength and Conditioning.* (2021).

10. Owen, A. L., Wong, D. P., Newton, M., **Weldon, A**., Zhang, Q. & Koundourakis, N. Quantification, tapering and positional analysis of across 9-weekly microcycles in a professional Chinese Super League soccer team. *EC Orthopaedics.* **12,** 39–56 (2020).
11. Bishop, C., **Weldon, A**., Hughes, J., Brazier, J., Loturco, I., Turner, A. & Read, P. Seasonal variation of physical performance inter-limb asymmetry in professional cricket athletes. *Journal of Strength and Conditioning Research*. **35**, 941–948 (2020).
12. **Weldon, A**., Clarke, N.D., Pote, L. & Bishop, C. Physical profiling of international cricket players: an investigation between bowlers and batters. *Biology of Sport*. **38**, 507–515 (2020).
13. Wong, D. P., **Weldon, A**. & Ngo, J. K. Physical fitness improvements of 8-week light vs. heavy tyre flip training in young adults. *Biology of Sport.* **37**, 203–210 (2020).
14. **Weldon, A**. & Ngo, J. K. The effects of work-integrated learning on undergraduate sports coaching students' perceived self-efficacy. *International Journal of Work Integrated Learning*. **20**, 309–319 (2019).
15. Mateus, N., Gonçalves, B., **Weldon, A**. & Sampaio, J. Effects of using four baskets during simulated youth basketball games. *PLoS One* (2019) doi: 10.1371/journal.pone.0221773.
16. Duncan, M. J., **Weldon, A**. & Price, M. The effects of sodium bicarbonate ingestion on back squat and bench press exercise to failure. *Journal of Strength and Conditioning Research*. **28**, 1358–1366 (2014).

References

1. Reid, C., Stewart, E. & Thorne, G. Multidisciplinary sport science teams in elite sport: comprehensive servicing or conflict and confusion? *Sport Psychol.* **18**, 204–217 (2004).
2. Rohde, M. & Breuer, C. Europe's elite football: financial growth, sporting success, transfer investment, and private majority investors. *Int. J. Financ. Stud.* **4**, 12 (2016).
3. Smith, J. & Smolianov, P. The high performance management model: from Olympic and professional to university sport in the United States. *The Sport Journal* https://thesportjournal.org/article/the-high-performance-management-model-from-olympic-and-professional-to-university-sport-in-the-united-states/ (2016).
4. Sousa, T. The role of a strength and conditioning coach. in *The Sports Medicine Physician* 107–119 (Springer, 2019).
5. Gamble, P. Strength and conditioning' theory and practice - A need to know. *N. Z. J. Sports Med.* **42**, 24–28 (2015).
6. Stewart, P., Comfort, P & Turner, A. Strength and conditioning coach or scientist? in *Advanced strength and conditioning: an evidence-based approach.* 1–10 (Routledge, 2017).
7. Vernau, J. *et al.* An analysis of job descriptions and person specifications to define the requirements for obtaining employment within strength and conditioning. *Prof. Strength Cond.* 7–18 (2021).
8. Ebben, W. & Blackard, D. Strength and conditioning practices of National Football League strength and conditioning coaches. *J. Strength Cond. Res.* **15**, 48–58 (2001).
9. Ebben, W., Carroll, R. & Simenz, C. Strength and conditioning practices of National Hockey League strength and conditioning coaches. *J. Strength Cond. Res.* **18**, 889–897 (2004).
10. Ebben, W., Hintz, M. & Simenz, C. Strength and conditioning practices of Major League Baseball strength and conditioning coaches. *J. Strength Cond. Res.* **19**, 538–546 (2005).

11. Simenz, C. J., Dugan, C. A. & Ebben, W. P. Strength and conditioning practices of National Basketball Association strength and conditioning coaches. *J. Strength Cond. Res.* **19**, 495–504 (2005).
12. Jamshidi, F. S., Mirzeai, B. & Damirchi, A. Strength and conditioning practices of Iran wrestling league strength and conditioning coaches. *Pedagog. Psychol. Med.-Biol. Probl. Phys. Train. Sports* **18**, 34–45 (2014).
13. Pote, L., King, G. & Christie, C. Strength and conditioning practices of franchise-level cricket trainers. *South Afr. J. Sports Med.* **32**, 1–5 (2020).
14. Jones, T. W., Smith, A., Macnaughton, L. S. & French, D. N. Strength and conditioning and concurrent training practices in elite rugby union. *J. Strength Cond. Res.* **30**, 3354–3366 (2016).
15. Crowley, E., Harrison, A. J. & Lyons, M. Dry-land resistance training practices of elite swimming strength and conditioning coaches. *J. Strength Cond. Res.* **32**, 2592–2600 (2018).
16. Shurley, J. P., Ednie, A. J. & Rudebeck, T. J. Strength and conditioning practices of head coaches of male and female interscholastic sport teams. *J. Strength Cond. Res.* **34**, 1894–1902 (2020).
17. Gee, T. I., Olsen, P. D., Berger, N. J., Golby, J. & Thompson, K. G. Strength and conditioning practices in rowing. *J. Strength Cond. Res.* **25**, 668–682 (2011).
18. Pote, L. & Christie, C. J. Strength and conditioning practices of university and high school level cricket coaches: a South African context. *J. Strength Cond. Res.* **30**, 3464–3470 (2016).
19. Robinson, B., Pote, L. & Christie, C. Strength and conditioning practices of high school rugby coaches: a South African context. *South Afr. J. Sci.* **115**, 9–10 (2019).
20. Healy, R., Kenny, I. C. & Harrison, A. J. Resistance training practices of sprint coaches. *J. Strength Cond. Res.* **35**, 1939–1948 (2019).
21. Weakley, J. J. S. *et al.* Strength and conditioning practices in adolescent rugby players: relationship with changes in physical qualities. *J. Strength Cond. Res.* **33**, 2361–2369 (2019).
22. Winwood, P. W., Keogh, J. W. L. & Harris, N. K. The strength and conditioning practices of strongman competitors. *J. Strength Cond. Res.* **25**, 3118–3128 (2011).

23. Ebben, W. P. & Suchomel, T. J. Physical demands, injuries, and conditioning practices of stock car drivers. *J. Strength Cond. Res.* **26**, 1188–1198 (2012).
24. Blagrove, R. C., Brown, N., Howatson, G. & Hayes, P. R. Strength and conditioning habits of competitive distance runners. *J. Strength Cond. Res.* **34**, 1392–1399 (2020).
25. Luczak, T., Burch, R., Lewis, E., Chander, H. & Ball, J. State-of-the-art review of athletic wearable technology: what 113 strength and conditioning coaches and athletic trainers from the USA said about technology in sports. *Int. J. Sports Sci. Coach.* **15**, 26–40 (2019).
26. Baptista, A. *et al.* The doctorate as an original contribution to knowledge: considering relationships between originality, creativity, and innovation. *Frontline Learn. Res.* **3**, 55–67 (2015).
27. Phillips, E. & Pugh, D. *How to get a PhD: a handbook for students and their supervisors.* (Open University Press, 2010).
28. Bishop, C. *et al.* The future development pathway of strength and conditioning: a proposed model from the UKSCA. *Prof. Strength Cond.* 30–34 (2019).
29. Collins, D., Moody, J. & Downes, P. Considerations for effective coaching in strength and conditioning. in *Strength and conditioning for sports performance* 3–11 (Routledge, 2021).
30. Who is the NSCA? *National Strength and Conditioning Association* https://www.nsca.com/about-us/about-us/ (2021).
31. McGuigan, M. Principles of test selection and administration. in *Essentials of strength training and conditioning.* 249–258 (Human Kinetics., 2016).
32. McGuigan, M. Administration, scoring, and interpretation of selected tests. in *Essentials of strength training and conditioning.* 259–316 (Human Kinetics., 2016).
33. Nakata, H., Nagami, T., Higuchi, T., Sakamoto, K. & Kanosue, K. Relationship between performance variables and baseball ability in youth baseball players. *J. Strength Cond. Res.* **27**, 2887–2897 (2013).
34. Spaniol, F. J. *et al.* The relationship between static strength, rotational strength, rotational power, bat speed, and batted-ball velocity of NCAA division I baseball players. **24**, (2010).
35. MLB Standings. https://www.mlb.com/standings/2019. (2019).
36. FIFA Big Count 2006: 270 million people active in football. (2007).

37. Caruso, R., Addesa, F. & Di Domizio, M. The determinants of the TV demand for soccer: empirical evidence on Italian Serie A for the period 2008-2015. *J. Sports Econ.* **20**, 25–49 (2019).
38. Turner, A. N. & Stewart, P. F. Strength and conditioning for soccer players. *Strength Cond. J.* **36**, 1–13 (2014).
39. Haff, G. & Triplett, N. *Essentials of strength training and conditioning.* (Human Kinetics, 2016).
40. Springham, M., Walker, G., Strudwick, T. & Turner, A. Developing strength and conditioning coaches for professional football. *Prof. Strength Cond.* 9–16 (2018).
41. Bloomfield, J., Polman, R. & O'Donoghue, P. Physical demands of different positions in FA Premier League soccer. *J. Sports Sci. Med.* **6**, 63–70 (2007).
42. McQuilliam, S. J., Clark, D. R., Erskine, R. M. & Brownlee, T. E. Mind the gap! A survey comparing current strength training methods used in men's versus women's first team and academy soccer. *Sci. Med. Footb.* (2022) doi:10.1080/24733938.2022.2070267.
43. Abbott, W., Brickley, G. & Smeeton, N. J. Physical demands of playing position within English Premier League academy soccer. *J. Hum. Sport Exerc.* **13**, 285–295 (2018).
44. Bangsbo, J. Physiological demands of football. *Sports Sci. Exch.* **27**, 1–6 (2014).
45. Slimani, M. & Nikolaidis, P. T. Anthropometric and physiological characteristics of male soccer players according to their competitive level, playing position and age group: a systematic review. *J. Sports Med. Phys. Fitness* **59**, 141–163 (2019).
46. Bompa, T., O. & Buzzichelli, C., A. Individualization. in *Periodization: theory and methodology of training* 36–40 (Human Kinetics, 2017).
47. Haff, G., G. Periodization. in *Essentials of strength training and conditioning* 583–604 (Human Kinetics, 2016).
48. Silva, J. R., Nassis, G. P. & Rebelo, A. Strength training in soccer with a specific focus on highly trained players. *Sports Med. - Open* **1**, 17 (2015).
49. Walker, G. & Hawkins, R. Structuring a program in elite professional soccer. *Strength Cond. J.* **40**, 72–82 (2018).

50. Newton, M. D., Owen, A. L. & Baker, J. S. Monitoring external and internal training loads: relationships with injury risk in professional soccer: a review. *EC Orthop.* **10**, 686–697 (2019).
51. Weldon, A. *et al.* Practices of strength and conditioning coaches: a snapshot from different sports, countries, and expertise levels. *J. Strength Cond. Res.* (2020) doi:10.1519/JSC.0000000000003773.
52. Turner, A. *et al.* Data analysis for strength and conditioning coaches: using excel to analyze reliability, differences, and relationships. *Strength Cond. J.* **37**, 76–83 (2015).
53. McFarland, M. & Bird, S., P. A wellness monitoring tool for youth athletes. *J. Aust. Strength Cond.* **22**, 22–26 (2014).
54. Talpey, S. & Siesmaa, E. Sports injury prevention: the role of the strength and conditioning coach. *Strength Cond. J.* **39**, 14–19 (2017).
55. Herridge, R., Turner, A. & Bishop, C. Monitoring changes in power, speed, agility, and endurance in elite cricketers during the off-season period. *J. Strength Cond. Res.* **34**, 2285–2293 (2020).
56. Petersen, C., Pyne, D. B., Portus, M. R. & Dawson, B. Quantifying positional movement patterns in Twenty20 cricket. *Int. J. Perform. Anal. Sport* **9**, 165–170 (2009).
57. Petersen, C. J., Pyne, D., Dawson, B., Portus, M. & Kellett, A. Movement patterns in cricket vary by both position and game format. *J. Sports Sci.* **28**, 45–52 (2010).
58. Sholto-Douglas, R., Cook, R., Wilkie, M. & Christie, C. J.-A. Movement demands of an elite cricket team during the Big Bash League in Australia. *J. Sports Sci. Med.* **19**, 59–64 (2020).
59. Pardiwala, D. N., Rao, N. N. & Varshney, A. V. Injuries in cricket. *Sports Health* **10**, 217–222 (2018).
60. Taliep, M. S., Prim, S. K. & Gray, J. Upper body muscle strength and batting performance in cricket batsmen. *J. Strength Cond. Res.* **24**, 3484–3487 (2010).
61. Cronin, J. *et al.* Strength and conditioning for throwing in cricket. *Strength Cond. J.* **38**, 1 (2016).
62. McGuigan, M. R., Wright, G. A. & Fleck, S. J. Strength training for athletes: does it really help sports performance? *Int. J. Sports Physiol. Perform.* **7**, 2–5 (2012).

63. Malone, J. J. *et al.* Seasonal training-load quantification in elite English premier league soccer players. *Int. J. Sports Physiol. Perform.* **10**, 489–497 (2015).
64. Turner, A. The science and practice of periodization: a brief review. *Strength Cond. J.* **33**, 34–46 (2011).
65. Sánchez-Moreno, J., Afonso, J., Mesquita, I. & Ureña, A. Dynamics between playing activities and rest time in high-level men's volleyball. *Int. J. Perform. Anal. Sport* **16**, 317–331 (2016).
66. FIVB (Federation Internationale de Volleyball): The Game. https://www.fivb.com/en/volleyball/thegame_glossary/basicvolleyballrules (2021).
67. Hedrick, A. Training for high level performance in women's collegiate volleyball: part I training requirements. *Strength Cond. J.* **29**, 50–53 (2007).
68. Marques, M. C., Tillaar, R. van den, Vescovi, J. D. & González-Badillo, J. J. Changes in strength and power performance in elite senior female professional volleyball players during the in-season: a case study. *J. Strength Cond. Res.* **22**, 1147–1155 (2008).
69. Holmberg, P. M. Weightlifting to improve volleyball performance. *Strength Cond. J.* **35**, 79–88 (2013).
70. Bunn, J. A., Ryan, G. A., Button, G. R. & Zhang, S. Evaluation of strength and conditioning measures with game success in division I collegiate volleyball: a retrospective study. *J. Strength Cond. Res.* **34**, 183–191 (2020).
71. Marques, M. C., Tillaar, R. van den, Gabbett, T. J., Reis, V. M. & González-Badillo, J. J. Physical fitness qualities of professional volleyball players: determination of positional differences. *J. Strength Cond. Res.* **23**, 1106–1111 (2009).
72. Bere, T., Kruczynski, J., Veintimilla, N., Hamu, Y. & Bahr, R. Injury risk is low among world-class volleyball players: 4-year data from the FIVB Injury Surveillance System. *Br. J. Sports Med.* **49**, 1132–1137 (2015).
73. Eerkes, K. Volleyball injuries. *Curr. Sports Med. Rep.* **11**, 251–256 (2012).
74. Reeser, J. C., Verhagen, E., Briner, W. W., Askeland, T. I. & Bahr, R. Strategies for the prevention of volleyball related injuries. *Br. J. Sports Med.* **40**, 594–600; discussion 599-600 (2006).

75. Marques, M. C., González-Badillo, J. J. & Kluka, D. A. In-season resistance training for professional male volleyball players. *Strength Cond. J.* **28**, 16–27 (2006).
76. FIVB Federation Internationale de Volleyball: The Federation. https://www.fivb.com/en/thefivb/structure (2021).
77. Seminati, E. & Minetti, A. E. Overuse in volleyball training/practice: a review on shoulder and spine-related injuries. *Eur. J. Sport Sci.* **13**, 732–743 (2013).
78. Pfirrmann, D., Herbst, M., Ingelfinger, P., Simon, P. & Tug, S. Analysis of injury incidences in male professional adult and elite youth soccer players: a systematic review. *J. Athl. Train.* **51**, 410–424 (2016).
79. Owoeye, O. B. A., VanderWey, M. J. & Pike, I. Reducing injuries in soccer (football): an umbrella review of best evidence across the epidemiological framework for prevention. *Sports Med. - Open* (2020) doi:10.1186/s40798-020-00274-7.
80. Brazilian Football Confederation. Raio X do Mercado. https://www.cbf.com.br/a-cbf/informes/index/raio-x-do-mercado-2019-numeros-gerais-de-registro. (2019).
81. López, A., M. Brazil: receipts for international FIFA transfers 2013-2019. https://www.statista.com/statistics/1070065/fifa-transfer-revenue-brazil/.
82. Guedes, S. L. On criollos and capoeiras: notes on soccer and national identity in Argentina and in Brazil. *Soccer Soc.* **15**, 147–161 (2014).
83. Paulucio, D. Monitoring of load in athletes of a league of the Brazilian championship. *Act. Física Deporte Cienc. Profesión* **15**, (2019).
84. Barnes, C., Archer, D. T., Hogg, B., Bush, M. & Bradley, P. S. The evolution of physical and technical performance parameters in the English Premier League. *Int. J. Sports Med.* **35**, 1095–1100 (2014).
85. Bush, M., Barnes, C., Archer, D. T., Hogg, B. & Bradley, P. S. Evolution of match performance parameters for various playing positions in the English Premier League. *Hum. Mov. Sci.* **39**, 1–11 (2015).
86. Dellal, A. *et al.* Comparison of physical and technical performance in European soccer match-play: FA Premier League and La Liga. *Eur. J. Sport Sci.* **11**, 51–59 (2011).

87. Loturco, I. *et al.* Half-squat or jump squat training under optimum power load conditions to counteract power and speed decrements in Brazilian elite soccer players during the preseason. *J. Sports Sci.* **33**, 1283–1292 (2015).
88. Loturco, I. *et al.* Power training in elite young soccer players: effects of using loads above or below the optimum power zone. *J. Sports Sci.* **38**, 1416–1422 (2019).
89. Meckel, Y., Harel, U., Michaely, Y. & Eliakim, A. Effects of a very short-term preseason training procedure on the fitness of soccer players. *J. Sports Med. Phys. Fitness* **54**, 432–440 (2014).
90. Weldon, A. *et al.* Contemporary practices of strength and conditioning coaches in professional soccer. *Biol. Sport* **38**, 377–390 (2020).
91. Yu, W., Lau, C. & Lee, J. C. Into collaborative research and co-authorship: experiences and reflections. *Reflective Pract.* **14**, 31–42 (2013).
92. Andrade, C. Internal, external, and ecological validity in research design, conduct, and evaluation. *Indian J. Psychol. Med.* **40**, 498–499 (2018).
93. Sorkness, C. A. *et al.* A new approach to mentoring for research careers: the National Research Mentoring Network. *BMC Proc.* **11**, 22 (2017).
94. Till, K., Muir, B., Abraham, A., Piggott, D. & Tee, J. A framework for decision-making within strength and conditioning coaching. *Strength Cond. J.* **41**, 14–26 (2019).
95. Kamler, B. Rethinking doctoral publication practices: writing from and beyond the thesis. *Stud. High. Educ.* **33**, 283–294 (2008).
96. Scarazzati, S. & Wang, L. The effect of collaborations on scientific research output: the case of nanoscience in Chinese regions. *Scientometrics* **121**, 839–868 (2019).
97. He, Z.-L., Geng, X.-S. & Campbell-Hunt, C. Research collaboration and research output: a longitudinal study of 65 biomedical scientists in a New Zealand university. *Res. Policy* **38**, 306–317 (2009).
98. Lee, S. & Bozeman, B. The impact of research collaboration on scientific productivity. *Soc. Stud. Sci.* **35**, 673–702 (2005).
99. Sutherland, K. A. The importance of critical reflection in and on academic development. *Int. J. Acad. Dev.* **18**, 111–113 (2013).

100. Till, K. *et al.* Optimising long-term athletic development: an investigation of practitioners' knowledge, adherence, practices and challenges. *PLOS ONE* **17**, e0262995 (2022).

Appendix A: Ethics approval documents

Note: Output [4] was a systematic review, which did not require ethics approval and output [7] was co-authored, therefore lead author Dr. Irineu Loturco arranged ethics approval.

Output 1.

Output 2.

Output 3.

Output 5.

Output 6.

Appendix B: Contribution statements of co-authors

I (Adam Owen) acknowledge the below statement to be true regarding my contribution to research output [6] outlined within Mr. Anthony Weldon's Ph.D. by publication.

Weldon, A., Wong, S. T., Mateus, N., Duncan, M. J., Clarke, N. D., Pears, M., Owen, A. L. & Bishop, C. Practices and perspectives of strength and conditioning in soccer coaches and players. *International Journal of Sports Science and Coaching* (2022) doi.org/10.1177/17479541211072242.

Dr. Adam Owen was invited to co-author output [6]. This was based on his extensive research and experience in soccer. He provided invaluable recommendations for the writing structure, literature support, and content for this output. Furthermore, proposed suitable revisions for the output before submission and during the review process.

Signature:

I (Anthony Turner) acknowledge the below statement to be true regarding my contribution to research outputs [1-4] outlined within Mr. Anthony Weldon's Ph.D. by publication.

Weldon, A., Duncan, M. J., Turner, A., LaPlaca, D., Sampaio, J. & Christie, C. J. Practices of strength and conditioning coaches: A snapshot from different sports, countries and levels. *Journal of Strength Conditioning Research* (2020) doi: 10.1519/JSC.0000000000003773.

Weldon, A., Duncan, M. J., Turner, A., Wong, D. P., Noon, M., Sampaio, J. & Lai, V. W. Contemporary practices of strength and conditioning coaches in professional soccer. *Biology of Sport.* **38**, 377-390 (2020).

Weldon, A., Duncan, M. J., Turner, A., Christie, C. J. & Pang, C. M. C. Contemporary practices of strength and conditioning coaches in professional cricket. *International Journal of Sports Science and Coaching.* **16**, 585-600 (2020).

Weldon, A., Duncan, M. J., Turner, A., Lockie, R. & Loturco, I. Practices of strength and conditioning coaches in professional sports: a systematic review. *Biology of Sport.* **39**, 715-726 (2021).

Assoc. Prof. Anthony Turner was central to designing the surveys used for outputs [1-3], where he provided valuable insight from an S&C researcher and practitioner perspective. Furthermore, to help outputs [1-3] reach the relevant participants, he made use of his extensive network in S&C. For output [4] he guided the development of the systematic review and shared ideas on how to best present the results. For all outputs [1-4], he made constructive and valuable contributions during the submission and review process.

Signature

I (Candice Christie) acknowledge the below statement to be true regarding my contribution to research outputs [1,3] outlined within Mr. Anthony Weldon's Ph.D. by publication.

Weldon, A., Duncan, M. J., Turner, A., LaPlaca, D., Sampaio, J. & Christie, C. J. Practices of strength and conditioning coaches: A snapshot from different sports, countries and levels. *Journal of Strength Conditioning Research* (2020) doi: 10.1519/JSC.0000000000003773.

Weldon, A., Duncan, M. J., Turner, A., Christie, C. J. & Pang, C. M. C. Contemporary practices of strength and conditioning coaches in professional cricket. *International Journal of Sports Science and Coaching.* **16**, 585-600 (2020).

Assoc. Prof. Candice Christie was integral to the conception of outputs [1, 3]. She had previously conducted similar research, therefore provided valuable experience and guidance on survey design and distribution, and data presentation. Furthermore, given her reputation and network in S&C and cricket in South Africa, she was integral to reaching this demographic for each survey. She also provided important recommendations for writing and structural improvements for each output and provided valuable guidance during the review process.

Signature

I (Cecilia Pang) acknowledge the below statement to be true regarding my contribution to research output [3] outlined within Mr. Anthony Weldon's Ph.D. by publication.

Weldon, A., Duncan, M. J., Turner, A., Christie, C. J. & Pang, C. M. C. Contemporary practices of strength and conditioning coaches in professional cricket. *International Journal of Sports Science and Coaching.* **16**, 585-600 (2020).

Ms. Cecilia Pang was integral to the collection of contact information for S&C coaches in output [3]. Furthermore, made useful sport-specific contributions during the write-up process, given her background in cricket. This made the paper read more clearly and allowed for meaningful practical applications to be made.

Signature:

I (Chris Bishop) acknowledge the below statement to be true regarding my contribution to research outputs [5-6] outlined within Mr. Anthony Weldon's Ph.D. by publication.

Weldon, A., Mak, J. T. S., Wong, S. T., Duncan, M. J., Clarke, N. D. & Bishop, C. Strength and conditioning practices and perspectives of volleyball coaches and players. *SPORTS.* (2021) doi.org/10.3390/sports9020028.

Weldon, A., Wong, S. T., Mateus, N., Duncan, M. J., Clarke, N. D., Pears, M., Owen, A. L. & Bishop, C. Practices and perspectives of strength and conditioning in soccer coaches and players. *International Journal of Sports Science and Coaching* (2022) doi.org/10.1177/17479541211072242.

Dr. Chris Bishop helped with the design of the two surveys used to investigate the S&C practices and perspectives of volleyball and soccer coaches and athletes in outputs [5-6]. Furthermore, he extensively advised on the format and content of each output and contributed well throughout the review process.

Signature:

I (David LaPlaca) acknowledge the below statement to be true regarding my contribution to research output [1] outlined within Mr. Anthony Weldon's Ph.D. by publication.

Weldon, A., Duncan, M. J., Turner, A., LaPlaca, D., Sampaio, J. & Christie, C. J. Practices of strength and conditioning coaches: A snapshot from different sports, countries and levels. *Journal of Strength Conditioning Research* (2020) doi: 10.1519/JSC.0000000000003773.

Dr. David LaPlaca had previously conducted survey-based research addressing the characteristics of different levels of S&C coaches in North America and Australia. Therefore, for output [1] he advised how to reach the targeted population (S&C coaches) and structure our survey, to ensure each question was presented appropriately. Furthermore, given his extensive connections in North America, he was crucial in distributing the survey within this region. He also reviewed output [1] several times, providing recommended changes before initial submission and during the review process.

Signature

I (Del Wong) acknowledge the below statement to be true regarding my contribution to research output [2] outlined within Mr. Anthony Weldon's Ph.D. by publication.

Weldon, A., Duncan, M. J., Turner, A., Wong, D. P., Noon, M., Sampaio, J. & Lai, V. W. Contemporary practices of strength and conditioning coaches in professional soccer. *Biology of Sport.* **38**, 377-390 (2020).

Prof. Del Wong was invited to co-author output [2]. This was based on his extensive research and experience in soccer. He provided invaluable recommendations for the writing structure, literature support, and content for this output. Furthermore, proposed suitable revisions for the output before submission and during the review process.

Signature:

I (Irineu Loturco) acknowledge the below statement to be true regarding my contribution to research outputs [4, 7] outlined within Mr. Anthony Weldon's Ph.D. by publication.

Weldon, A., Duncan, M. J., Turner, A., Lockie, R. & Loturco, I. Practices of strength and conditioning coaches in professional sports: a systematic review. *Biology of Sport.* **39**, 715-726 (2021).

Loturco, I., Freitas, T. T., Alcaraz, P. E., Kobal, R., Nunes, R., **Weldon, A**. & Pereira, L. A. Practices of strength and conditioning coaches in Brazilian elite soccer. *Biology of Sport.* **39**, 779-791 (2021).

Dr. Irineu Loturco was invited to co-author output [4], given his extensive research and practical experience in S&C. He provided advice on how to interpret the results from the systematic review generally and specifically for each sport. Hereafter, we discussed conducting a paper to investigate the practices of S&C coaches in professional Brazilian soccer, which eventually formed output [7]. This also served the purpose of building upon outputs [2, 6], which looked at S&C practices in soccer across different countries and specifically in Hong Kong. For output [7], Dr. Loturco adapted the surveys used in outputs [1-3] and led the data collection, analysis, and write-up.

Signature:

I (Jaime Sampaio) acknowledge the below statement to be true regarding my contribution to research outputs [1-2] outlined within Mr. Anthony Weldon's Ph.D. by publication.

1. **Weldon, A**., Duncan, M. J., Turner, A., LaPlaca, D., Sampaio, J. & Christie, C. J. Practices of strength and conditioning coaches: A snapshot from different sports, countries and levels. *Journal of Strength Conditioning Research* (2020) doi: 10.1519/JSC.0000000000003773.
2. **Weldon, A**., Duncan, M. J., Turner, A., Wong, D. P., Noon, M., Sampaio, J. & Lai, V. W. Contemporary practices of strength and conditioning coaches in professional soccer. *Biology of Sport.* **38**, 377-390 (2020).

Prof. Jaime Sampaio assisted with the survey design, distribution, and write-up of output [1]. For output [2], he primarily advised on the modifications of the survey to address S&C coaches in soccer and provided important changes and recommendations for the final version submitted. For both outputs, he discussed with me how to present data concisely in a reader-friendly format.

Signature:

I (Jason Mak) acknowledge the below statement to be true regarding my contribution to research output [5] outlined within Mr. Anthony Weldon's Ph.D. by publication.

Weldon, A., Mak, J. T. S., Wong, S. T., Duncan, M. J., Clarke, N. D. & Bishop, C. Strength and conditioning practices and perspectives of volleyball coaches and players. *SPORTS* (2021) doi.org/10.3390/sports9020028.

Mr. Jason Mak is a respected coach within the Hong Kong volleyball community. He was imperative to the design and distribution of the survey used for output [5]. Moreover, provided local and sport-specific guidance, which led to a smooth data collection and analysis process. He contributed well to the final paper, particularly from a volleyball perspective.

Signature:

I (Mark Noon) acknowledge the below statement to be true regarding my contribution to research output [2] outlined within Mr. Anthony Weldon's Ph.D. by publication.

Weldon, A., Duncan, M. J., Turner, A., Wong, D. P., Noon, M., Sampaio, J. & Lai, V. W. Contemporary practices of strength and conditioning coaches in professional soccer. *Biology of Sport*. **38**, 377-390 (2020).

Dr. Mark Noon was invited to co-author output [2]. This was based on his extensive research and experience in soccer. He provided invaluable recommendations for the writing structure, literature support, and content for this output. Furthermore, proposed suitable revisions for the output before submission and during the review process.

Signature:

I (Matt Pears) acknowledge the below statement to be true regarding my contribution to research output [6] outlined within Mr. Anthony Weldon's Ph.D. by publication.

Weldon, A., Wong, S. T., Mateus, N., Duncan, M. J., Clarke, N. D., Pears, M., Owen, A. L. & Bishop, C. Practices and perspectives of strength and conditioning in soccer coaches and players. *International Journal of Sports Science and Coaching* (2022) doi.org/10.1177/17479541211072242.

Mr. Matt Pears is a respected strength and conditioning coach within the Hong Kong soccer community. He was imperative to the design and distribution of the survey used for output [6]. Moreover, provided local and sport-specific guidance, which led to a smooth data collection and analysis process. He, contributed well to the final paper, particularly from a soccer perspective.

Signature:

I (Michael Duncan) acknowledge the below statement to be true regarding my contribution to research outputs [1-6] outlined within Mr. Anthony Weldon's Ph.D. by publication.

Weldon, A., Duncan, M. J., Turner, A., LaPlaca, D., Sampaio, J. & Christie, C. J. Practices of strength and conditioning coaches: A snapshot from different sports, countries and levels. *Journal of Strength Conditioning Research* (2020) doi: 10.1519/JSC.0000000000003773.

Weldon, A., Duncan, M. J., Turner, A., Wong, D. P., Noon, M., Sampaio, J. & Lai, V. W. Contemporary practices of strength and conditioning coaches in professional soccer. *Biology of Sport.* **38**, 377-390 (2020).

Weldon, A., Duncan, M. J., Turner, A., Christie, C. J. & Pang, C. M. C. Contemporary practices of strength and conditioning coaches in professional cricket. *International Journal of Sports Science and Coaching.* **16**, 585-600 (2020).

Weldon, A., Duncan, M. J., Turner, A., Lockie, R. & Loturco, I. Practices of strength and conditioning coaches in professional sports: a systematic review. *Biology of Sport.* **39**, 715-726 (2021).

Weldon, A., Mak, J. T. S., Wong, S. T., Duncan, M. J., Clarke, N. D. & Bishop, C. Strength and conditioning practices and perspectives of volleyball coaches and players. *SPORTS* (2021) doi.org/10.3390/sports9020028.

Weldon, A., Wong, S. T., Mateus, N., Duncan, M. J., Clarke, N. D., Pears, M., Owen, A. L. & Bishop, C. Practices and perspectives of strength and conditioning in soccer coaches and players. *International Journal of Sports Science and Coaching* (2022) doi.org/10.1177/17479541211072242.

Prof. Michael Duncan was responsible for overseeing outputs [1-6] and provided guidance from conceptualization to submission. He patiently discussed his experience in role delegation, project management, paper submission, and the review process with me. This was especially important when submitting the initial outputs of this portfolio.

Furthermore, he played a key role in the design of each survey, and the write-up and revision of each paper.

Signatur

I (Neil Clarke) acknowledge the below statement to be true regarding my contribution to research outputs [5-6] outlined within Mr. Anthony Weldon's Ph.D. by publication.

Weldon, A., Mak, J. T. S., Wong, S. T., Duncan, M. J., Clarke, N. D. & Bishop, C. Strength and conditioning practices and perspectives of volleyball coaches and players. *SPORTS* (2021) doi.org/10.3390/sports9020028.

Weldon, A., Wong, S. T., Mateus, N., Duncan, M. J., Clarke, N. D., Pears, M., Owen, A. L. & Bishop, C. Practices and perspectives of strength and conditioning in soccer coaches and players. *International Journal of Sports Science and Coaching* (2022) doi.org/10.1177/17479541211072242.

Assoc. Prof. Neil Clarke helped with the design of the two surveys used to investigate the S&C practices and perspectives of volleyball and soccer coaches and athletes in outputs [5-6]. Furthermore, he extensively advised on the format and content of each output and contributed well throughout the review process.

Signature

I (Nuno Mateus) acknowledge the below statement to be true regarding my contribution to research output [6] outlined within Mr. Anthony Weldon's Ph.D. by publication.

Weldon, A., Wong, S. T., Mateus, N., Duncan, M. J., Clarke, N. D., Pears, M., Owen, A. L. & Bishop, C. Practices and perspectives of strength and conditioning in soccer coaches and players. *International Journal of Sports Science and Coaching* (2022) doi.org/10.1177/17479541211072242.

Mr. Nuno Mateus was invited to co-author output [6]. This was based on his extensive research and experience in soccer. He provided invaluable recommendations for the writing structure, literature support, and content for this output. Furthermore, proposed suitable revisions for the output before submission and during the review process.

Signature:

I (Robert Lockie) acknowledge the below statement to be true regarding my contribution to research output [4] outlined within Mr. Anthony Weldon's Ph.D. by publication.

Weldon, A., Duncan, M. J., Turner, A., Lockie, R. & Loturco, I. Practices of strength and conditioning coaches in professional sports: a systematic review. *Biology of Sport.* **39**, 715-726 (2021).

Asst. Prof. Robert Lockie co-authored output [4] and provided a vast amount of knowledge and experience in S&C. Given this was the first systematic review I have completed he provided useful advice on how to structure the paper and report the most significant findings. He also made extensive comments on how to improve the paper before initial submission and during the peer-review process.

Signature

I (Sing Wong) acknowledge the below statement to be true regarding my contribution to research outputs [5-6] outlined within Mr. Anthony Weldon's Ph.D. by publication.

Weldon, A., Mak, J. T. S., Wong, S. T., Duncan, M. J., Clarke, N. D. & Bishop, C. Strength and conditioning practices and perspectives of volleyball coaches and players. *SPORTS* (2021) doi.org/10.3390/sports9020028.

Weldon, A., Wong, S. T., Mateus, N., Duncan, M. J., Clarke, N. D., Pears, M., Owen, A. L. & Bishop, C. Practices and perspectives of strength and conditioning in soccer coaches and players. *International Journal of Sports Science and Coaching* (2022) doi.org/10.1177/17479541211072242.

Mr. Sing Wong is a graduate of THEi, who also completed a master's degree in S&C at Middlesex University (England) and obtained NSCA CSCS status. He is now employed at THEi as a physical education officer. Given the population reached for outputs [5-6] being from Hong Kong, all information relating to the study (e.g., survey) was presented in Cantonese and English, which Sing handled. Furthermore, some responses were received in Cantonese, therefore Sing translated these back into English before analysis. He also reviewed each output once written and made useful recommended changes.

Signature:

I (Vivian Lai) acknowledge the below statement to be true regarding my contribution to research output [2] outlined within Mr. Anthony Weldon's Ph.D. by publication.

Weldon, A., Duncan, M. J., Turner, A., Wong, D. P., Noon, M., Sampaio, J. & Lai, V. W. Contemporary practices of strength and conditioning coaches in professional soccer. *Biology of Sport*. **38**, 377-390 (2020).

Ms. Vivian Lai was integral to the collection of contact information for S&C coaches in output [2]. Furthermore, made useful sport-specific contributions during the write-up process, given her background in soccer. This made the paper read more clearly and allowed for meaningful practical applications to be made.

Signature:

Appendix C: Full text of each output

Note: Outputs [1,2,4,5,7] are available open-access with no copyright restrictions. Whereas, outputs [3,6] are unavailable due to copyright restrictions.

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Practices of Strength and Conditioning Coaches: A Snapshot From Different Sports, Countries, and Expertise Levels

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Abstract

Weldon, A, Duncan, MJ, Turner, A, LaPlaca, D, Sampaio, J, and Christie, CJ. Practices of strength and conditioning coaches: a snapshot from different sports, countries, and expertise levels. *J Strength Cond Res* XX(X): 000–000, 2020—This study describes the practices of strength and conditioning coaches (SCCs) from different sports, countries, and expertise levels. One hundred fifty-six SCCs (31.9 ± 8.9 years old) completed an online survey, consisting of 40 questions (36 fixed response and 4 open-ended), with 8 sections as follows: (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) programming and any additional comments. Responses were received from 48 sports and 17 countries. This study provides exploratory evidence incorporating responses primarily in soccer (45%), track and field (30%), volleyball (23%), golf (17%), and tennis (17%). A bachelor's degree or higher were held by 99% of SCCs, of which 94% were in a sports science–related field, and 71% held a strength and conditioning related certification or accreditation. Periodization strategies and physical testing were used by 96% and 94% of SCCs respectively. The hang clean (82%), power clean (76%), and clean high pull (63%) were the most prescribed Olympic weightlifting exercises. Multiple hops/lunges (84%) were the most prescribed plyometrics exercises. For open-ended questions, 40% of SCCs wanted to integrate more technology into their programs and 30% believed technology will be the main future trend. Strength and conditioning coaches from different sports, countries, and expertise levels can use the information presented in this study to review their current practices and provide a source of new ideas for diversifying or modifying future practices.

Key Words: survey, exercise selection, physical development, programming, physical testing, technology

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Contemporary practices of strength and conditioning coaches in professional soccer

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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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Practices of strength and conditioning coaches in professional sports: a systematic review

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ABSTRACT: The practices of strength and conditioning (S&C) coaches have been reported in various professional sports. This study aims to comprehensively assess this available evidence to help establish whether theoretical, practical, and evidence-based guidelines align with the practices employed by these experienced S&C coaches. Three databases were searched (PubMed, SPORTDiscus, and Cochrane) until November 2020. Studies surveying the practices of S&C coaches in professional sports using a survey design with common questions, written in English, and published in peer-reviewed journals were reviewed. Eight studies (n = 318 S&C coaches) were finally included. All studies adapted a similar survey, providing a strong basis for comparison between sports. Periodization strategies were widely used (89%), with training volume consistently reduced during the in-season period. Olympic weightlifting was commonly used across sports, except in baseball (29%). Plyometric exercises were predominantly prescribed for speed development (74%) and lower body power (68%), which were mostly programed as complex training (45%) and conducted all year round (52%). Flexibility exercises were mostly performed before practice (83%) for 6–10 min (40%). Physical tests were mainly conducted during the pre-season period (66%), with body composition (86%) being the most used test. S&C coaches generally adhered to current guidelines and research in S&C concerning training prescription and physical testing. Whereas, inter-sport differences were also noted and further discussed. Results of this study can be used by S&C coaches to plan, implement, and review their professional practices. Furthermore, may inform the development of general and sport-specific guidelines, and future research in S&C.

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Strength and Conditioning Practices and Perspectives of Volleyball Coaches and Players

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Abstract: To the authors' knowledge this is the first study to describe the strength and conditioning (S&C) practices and perspectives of volleyball coaches and players. In total, 30 volleyball coaches (mean age 34.47 ± 7.83 years and coaching experience 19.57 ± 8.28 years), and 30 volleyball players (mean age 22.03 ± 4.43 years and playing experience 10.43 ± 8.98 years) completed an online survey with six sections: (a) informed consent; (b) background information; (c) education, qualifications, and prescription; (d) views on S&C; (e) exercise selection and preferences; and (f) issues and improvements. Frequency analysis was used to report responses to fixed-response questions and thematic-analysis for open-ended questions. While only one participant possessed an S&C certification, S&C was deemed 'important' to 'very important' for volleyball skills, physical fitness, and injury parameters. However, due to a reported lack of expertise, there appeared to be a theoretical understanding to practice gap. Furthermore, the implementation of S&C was considerably hindered by a lack of time, facilities, and equipment. National sports associations, coaches, and players can use the information within this study to provide an understanding of the current practices and perspectives of S&C in volleyball. While also promoting future developments in volleyball related S&C research and practice.

Keywords: exercise selection; physical development; programing; sport; fitness; injury

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1. Introduction

Volleyball is a globally participated sport with 222 member federations and over 500 million registered players [1,2]. Playing positions include outside hitter, middle blocker, opposite, setter, libero, and defensive specialist [3]. The objective is to hit the ball over the net within the specified court dimensions and prevent the opposing team from returning the ball [3].

Beyond the technical and tactical requirements of volleyball, strength, power, and speed are considered the most significant factors determining competitive performance [4,5]. These physical attributes are required during rallies, which involve explosive movements such as spiking, blocking, and diving [3,6]. Work-to-rest ratios in high-level male volleyball players are approximately 1:6 (4.99 s of work to 29.02 s rest), therefore it is considered a high-intensity anaerobic sport [6–8].

To develop high-performing and robust volleyball athletes, strength and conditioning (S&C) programs with progressively overloaded whole-body exercises and position-specific movements are recommended [4]. It is important to concurrently develop general strength, power, and speed, to help underpin sport-specific training, performance, and injury reduction [4]. In particular, plyometrics are essential to volleyball training and can develop

players' performance in vertical and horizontal jumping, strength, flexibility, speed, and agility [8]. The prescription of plyometrics should be individualized for each athlete's physical ability and playing position, as significant differences have been observed for upper body and lower body strength [9], lower body power, and sprint performance [10] across playing positions.

Repetitive jumping, landing, hitting, and blocking movements conducted in volleyball can increase injury prevalence of the ankles, knees, lower back, and shoulders [11–13]. However, volleyball is deemed relatively safe with an injury incidence of elite players during match play being 10.7/1000 h played, with 32.5% of all injuries causing subsequent time-loss 3.8/1000 h played, which is similar across club and collegiate levels [11]. Injury prevention measures are still of high importance to ensure players are physically fit and available for selection [11,13]. This can be generally achieved through manipulating training load and volume, improving strength (particularly eccentric) and muscular endurance [12,13]. For example, to reduce overuse injuries of the knees an individualized S&C program is recommended, incorporating conditioning exercises of the thigh, hip, and core muscles to efficiently absorb landing forces from repetitive jumps [12,13].

Although the significance of physical development in volleyball is undeniable, there is limited literature on the actual training practices in this sport [14]. Research suggests significant relationships ($p \leq 0.05$) between structured S&C programs and volleyball position-specific game stats, including defensive specialists with squat and total strength; setters with hang cleans, T-drill, and broad jump; pin hitters with vertical jump, squat, and total strength; and middle blockers with broad jump [10]. However, not all teams have S&C coaches to design and implement their programs. Therefore, coaches, players, and support staff may be tasked with this responsibility.

Therefore, this study aims to assess the S&C practices and perspectives of volleyball coaches and players. To the authors' knowledge, this is the first study to specifically address this. Results from this study will help ascertain how well coaches' and players' practices align with current research and guidelines in S&C. In turn, this study will support the development of S&C education, practice, and research in volleyball.

2. Materials and Methods

2.1. Experimental Approach to the Problem

This study used an anonymous online survey to investigate the S&C practices and perspectives of volleyball coaches and players. The survey was adapted from previous research [15–17] and developed using the open-access survey application Google Forms. All information within the survey was presented in English and Chinese for clarity and understanding. The survey comprised six sections: (a) written informed consent; (b) background information; (c) education, qualifications, and prescription; (d) views on S&C; (e) exercise selection and preferences; and (f) issues and improvements. The coaches survey included 25 fixed-responses and 25 open-ended questions, and the players' survey included 24 fixed-responses and 25 open-ended questions (see Supplementary Appendix). The coaches' additional question was regarding the age range of volleyball athletes coached. Some questions allowed the selection of multiple-responses, meaning some questions had more responses than others. Pilot testing was conducted by each member of the research team, three volleyball coaches, and three volleyball players, for three rounds before the survey was finalized. This led to slight modifications to the wording and structure of the survey to ensure its validity for use with this population.

2.2. Subjects

Overall, 30 volleyball coaches and 30 volleyball players participated in this study. All were registered under the Volleyball Association of Hong Kong, China Limited. The inclusion criteria for coaches were (1) a qualified volleyball coach, and (2) players coached currently perform resistance training practices. The inclusion criteria for players were (1) currently playing in competitive level volleyball, and (2) currently performing resistance

training practices. All participants provided informed consent to initiate the survey. The survey started with an explanation of the purpose, aims, required time-commitment, and confidentiality of information.

2.3. Statistical Analyses

All responses from Google Forms were downloaded into a Microsoft Excel Spreadsheet. Fixed-response questions were assessed using frequency analysis. Open-ended response questions were assessed using thematic analysis [18], with 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 method of thematic analysis has been previously used in studies surveying S&C coaches [15–17,19,20]. Thereafter, overarching clear and identifiably distinct themes, representing the main ideas or patterns emerging from the raw data were generated for each question. Some responses provided sufficient information such that more than one overarching theme could be identified.

3. Results

3.1. Background Information

In total, 30 volleyball coaches (n = 21 male, n = 8 female, and n = 1 non-disclosed; mean age of 34.47 $\pm$ 7.83 years; mean coaching experience of 19.57 $\pm$ 8.28 years) and 30 volleyball players (n = 16 female, n = 14 male; mean age of 22.03 $\pm$ 4.43 years; mean playing experience of 10.43 $\pm$ 8.98 years) participated in this study.

The highest level of competition for coaches included Hong Kong Schools Sports Federation (HKSSF) (30%), Volleyball Association of Hong Kong, China Ltd. (VBAHK) League Division B/C (23%), VBAHK League Division A1/A2 (20%), Asian Volleyball Confederation (AVC) Competition (20%), Fédération Internationale de Volleyball (FIVB) International Competition (3%), and Other (3%). The highest level of competition for players included VBAHK League Division B/C (30%), AVC Competition (27%), VBAHK League Division A1/A2 (17%), University Sports Federation of Hong Kong, China Ltd. (USFHK) (17%), FIVB International Competition (10%).

The current roles of coaches consisted of head coach (73%), assistant coach (23%), and trainer (3%), and the age groups coached were 15–17 years (73.3%), above 18 years (47%), 12–14 years (40%), and below 12 years (20%). Players' predominant positions were outside hitter (47%), setter (27%), opposite (10%), middle blocker (10%), and libero (7%).

3.2. Education, Qualifications, and Prescription

Coaches' highest level of education was bachelor's degree (47%), master's degree (24%), higher diploma or associate degree (13%), and secondary school (17%), with 40% of qualifications being in a sports-related field. Players' highest level of education was bachelor's degree (50%), higher diploma or associate degree (47%), and secondary school (3%), with 53% of qualifications being in a sport-related field. Only one participant (a coach) (3%) held an S&C certification, which was with the United Kingdom Strength and Conditioning Association (UKSCA). Professional volleyball coaching certifications were held by 87% of coaches, with the following organizations and levels, VBAHK level one (43%), VBAHK level two (30%), FIVB level one (10%), FIVB level three (10%), and FIVB level two (7%). For players, 33% held coaching qualifications with the following organizations and levels, VBAHK level one (30%), and VBAHK level two (3%).

The prevalence of different sources used by coaches and players for S&C information, and personnel responsible for prescribing S&C exercises is displayed in Figures 1 and 2.

The prevalence of coaches and players perceived importance of S&C for different volleyball skills is displayed in Table 1, and for different physical, fitness, and injury parameters is displayed Table 2.

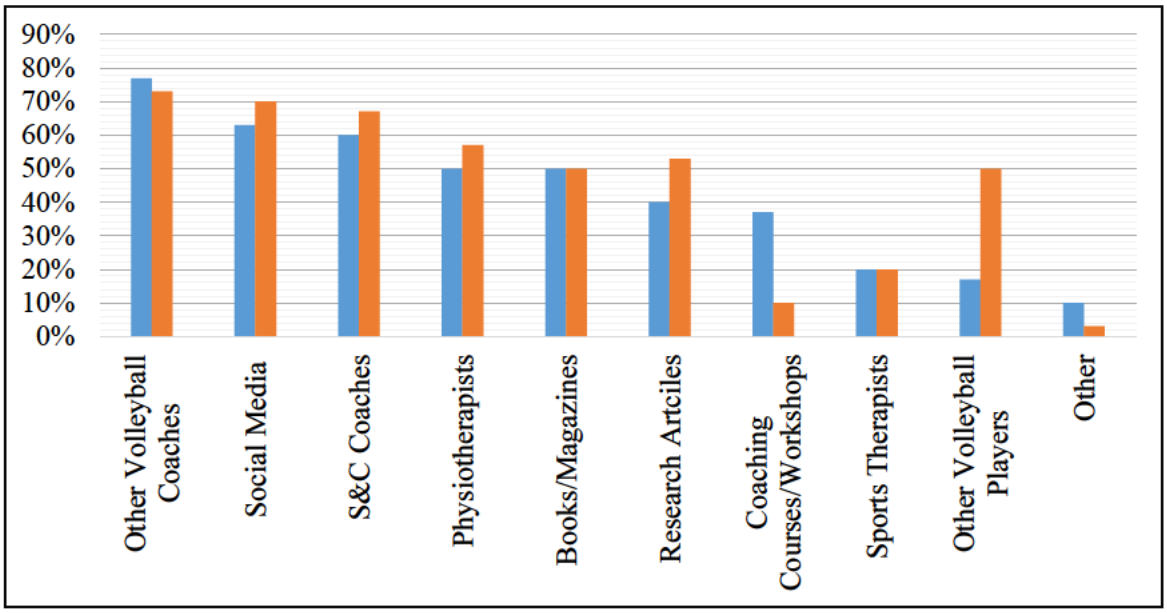

Figure 1. Percentage of coaches (blue) and players (orange) who obtain strength and conditioning information from different sources.

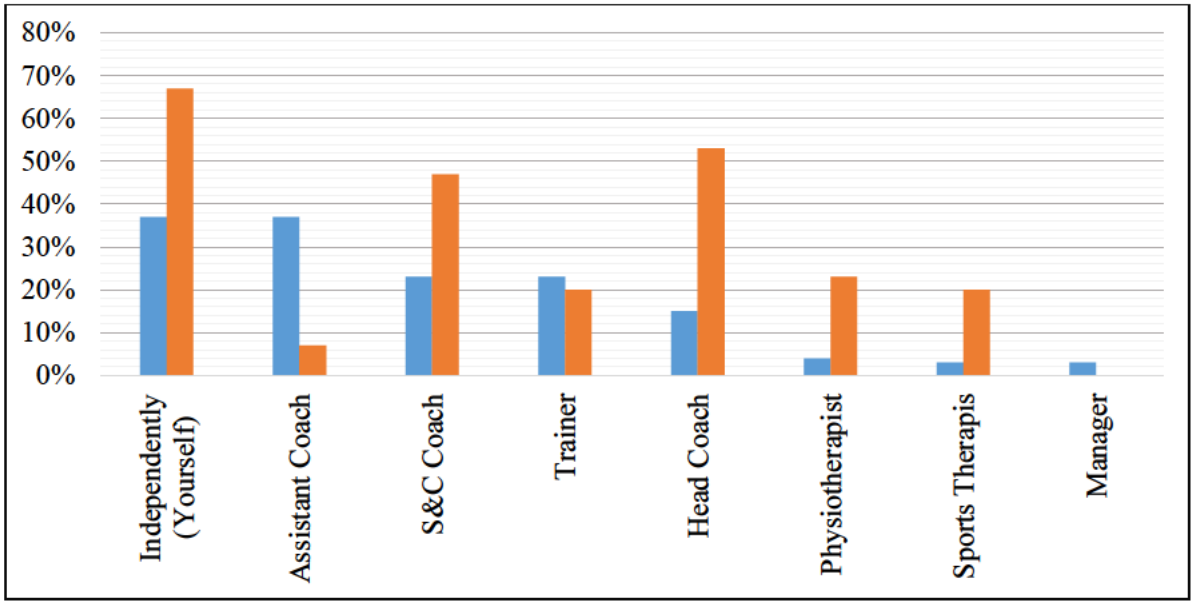

Figure 2. Percentage of coaches (blue) and players (orange) reporting the personnel responsible for prescribing strength and conditioning exercises.

3.3. Views on Strength and Conditioning

The importance of S&C for different volleyball skills is presented in Table 3, and for different physical, fitness, and injury parameters is presented in Table 4.

Coaches reported the effectiveness of their current S&C programs used with players to be moderately effective (53%), effective (23%), slightly effective (13%), and very effective (10%). Players reported the effectiveness of their current S&C programs to be effective (43%), moderately effective (33%), very effective (20%), and slightly effective (3%). Other responses from coaches included "insufficient training sessions and knowledge on fitness training", "players fitness levels cannot be enhanced/maintained without professional and systematic training arrangements", "training mainly focuses on bodyweight without training equipment and due to the busy school/work schedule the training time is insufficient in Hong

Kong compared to other countries. Therefore, physical improvements are non-significant", "lack of S&C knowledge", "players with high attendance showed improvements". Other responses from players included "I am not sure what is meant by effective. I have strength improvements, but I still feel pain in my previously injured shoulder", "no S&C coach available for planning fitness training. Our coach mainly focuses on ball practice", "reaction time is faster and strength has improved", "I continued my S&C training during the pandemic. Even with little volleyball training, I was able to maintain my performance", "it helps improve my performance and prevent injuries during training (e.g., maintains spiking power and endurance), which lowers my chance of injury when tired".

3.4. Exercise Selection and Preferences

The exercise preferences of coaches and players to develop different physical and volleyball-specific attributes, and to decrease the likelihood of injuries are presented in Table 5.

3.5. Issues and Improvements

The different issues, disadvantages and desired improvements coaches and players reported in regards to delivering S&C programs are presented in Table 6.

Table 1. The importance of strength and conditioning training for volleyball skills reported by coaches and players.

		Not Important (%)	Slightly Important (%)	Moderately Important (%)	Important (%)	Very Important (%)
Spiking	Coach	3	0	3	27	67
	Player	0	0	0	30	70
Blocking	Coach	0	3	0	33	63
	Player	0	0	0	30	70
Serving	Coach	0	0	10	47	43
	Player	0	0	17	43	40
Defending	Coach	0	3	3	23	70
	Player	0	0	0	47	53
Setting	Coach	0	3	7	33	57
	Player	0	3	7	47	43
Mean	Coach	0	1.8	4.6	32.6	60
	Player	0	0.6	4.8	39.4	55.2

Table 2. The importance of strength and conditioning training for different physical, fitness and injury parameters, reported by coaches and players.

		Not Important (%)	Slightly Important (%)	Moderately Important (%)	Important (%)	Very Important (%)
Strength	Coach	0	0	3.3	23.3	73.3
	Player	0	3.3	0	23.3	73.3
Power/Speed	Coach	0	0	0	20	80
	Player	0	0	0	23	77
Volleyball-Specific Fitness	Coach	0	0	3	27	70
	Player	0	0	0	27	73
Reducing Injuries	Coach	0	0	0	23	77
	Player	0	0	7	20	73
Injury Rehabilitation/ Return to Play	Coach	3.3	0	3.3	30	63.3
	Player	0	0	3.3	33.3	63.3
Mean	Coach	0.6	0.0	1.8	24.6	72.6
	Player	0.0	0.6	2.0	25.2	71.8

Table 3. Relative importance of strength and conditioning for different volleyball skills, reported by coaches and players.

Volleyball Skill	Rank	Theme	Exemplar Response	Percentage Coaches	Percentage Players	Percentage Difference
Spiking	1	Power/Speed	"Spiking requires power generated from the shoulder, forearm, and core"	60	67	−7
	2	Injury Reduction	"S&C helps decrease injuries when doing repetitive spike training"	30	27	3
	3	Strength	"Increased strength improves spiking ability"	30	23	7
	4	Jumping/Landing	"S&C training improves jumping ability for a higher spiking point"	23	20	3
	5	Coordination/Movement Quality	"Specific S&C can develop spiking movement and quality"	20	10	10
	6	Fitness/Endurance	"Good fitness and endurance enables high quality repeated jumps and spikes"	3	7	−4
	7	Miscellaneous	"Enhances the performance"	0	10	−10
Blocking	1	Jumping/Blocking Height	"Blocking height is determined by jumping ability, which can be improved with S&C"	53	43	10
	2	Speed/Power	"Develops movement speed and hangtime"	37	27	10
	3	Postural Control/Stiff Block	"Being able to perform a stiff block with good posture"	30	37	−7
	4	Injury Reduction	"Decreases injuries associated with muscle weakness or soreness"	27	3	24
	5	Strength	"Strength is the foundation for effective jumping and blocking"	13	37	−24
	6	Balance	"Helps keep balance while in the air"	10	0	10
	7	Agility	"Improves reaction time and agility"	7	0	7
	8	Fitness/Endurance	"Competing and blocking requires a certain level of fitness"	3	7	−4
Serving	1	Hitting Power	"The faster the arm swing the more powerful the serve"	60	60	0
	2	Injury Reduction	"Reduce the risk of shoulder injuries"	33	3	30
	3	Strength	"With the trend of jump serves, muscle strength plays an important role in smashing the ball"	30	3	27
	4	Coordination/Movement Quality	"Assists with body coordination especially for jump serves"	23	47	−24

Table 3. *Cont.*

Volleyball Skill	Rank	Theme	Exemplar Response	Percentage Coaches	Percentage Players	Percentage Difference
	5	Jump Height	"Jumping power is needed to increase the height of jump serve"	23	3	20
	6	Fitness/Endurance	"Improved fitness can help stabilize performance in the latter part of competition"	10	0	10
	7	Miscellaneous	"Controlling the technique of service is more important than muscle strength"	3	0	3
	8	Core	"Core muscles are required to stabilize the body"	0	10	−10
Defending	1	Reaction/Movement Speed	"Helps develop quickness and reaction speed which is important in defence"	60	47	13
	2	Fitness/Endurance	"Need to squat a long time so endurance in this position is key"	23	23	0
	3	Injury Reduction	"Due to high moving speed, S&C helps prevent injuries"	23	0	23
	4	Strength	"Volleyball defensive positions require high quadriceps and hamstrings muscle strength"	17	13	4
	5	Power	"S&C helps players possess enough power to defend effectively in games"	10	27	−17
	6	Miscellaneous	"Determining the defensive area"	7	0	7
	7	Flexibility/Mobility	"Mobility to get into defensive postures"	3	7	−4
Setting	1	Reaction/Movement Speed	"Setting from your teammate requires a quick response and fast movement"	37	13	24
	2	Stability	"Improves the stability of the jump set"	33	30	3
	3	Strength	"Strengthening the legs, core and arms is good for setting"	30	10	20
	4	Injury Reduction	"Decreases injury occurrence"	23	0	23
	5	Jumping	"Develops jumping ability for the jump set"	10	23	−13
	6	Fitness/Endurance	"Adequate cardiorespiratory fitness is required for repeated setting during competition"	7	0	7
	7	Miscellaneous	"To adapt to different tactics"	7	10	−3
	8	Balance/Coordination	"Helps with body balance during jump setting"	0	23	−23
	9	Power	"Power in the arms is needed to set the ball outside the hitter's spot"	0	17	−17

Some answers detailed more than one response, which was further sub-divided amongst the themes created.

Table 4. Perceived benefits of strength and conditioning for training different physical fitness and injury parameters, reported by coaches and players.

Physical, Fitness, and Injury Parameters	Rank	Theme	Exemplar Response	Percentage Coaches	Percentage Players	Percentage Difference
Strength	1	Improve Volleyball Performance	"Muscle strength is fundamental for high performing players and winning competitions"	33	17	16
	2	Strength	"Weight training is required to develop players strength"	30	47	−17
	3	Injury Reduction	"Reduces the risk of acute and chronic injuries"	27	0	27
	4	Power	"Power comes from a basis of strength, therefore needs to be trained"	13	37	−24
	5	Coordination/ Movement Quality	"Players can learn correct movement techniques and improve coordination on the court"	7	0	7
	6	Fitness	"Maintain enough fitness for competition"	7	7	0
	7	Miscellaneous	"The two are correlated"	7	3	4
Speed/ Power	1	Power/Speed	"Power is essential as players need to suddenly jump or move quickly to react"	57	63	−6
	2	Improve Volleyball Performance	"Improves volleyball performance in serving and spiking"	23	20	3
	3	Movement/ Coordination	"Enhances muscle coordination, and the correct contraction/relaxation of muscles"	23	13	10
	4	Injury Reduction	"Correct technique when conducting power exercises will help reduce injuries"	20	0	20
	5	Strength	"Strong muscles are required to support fast movements"	13	13	0
	6	Fitness	"Fitness training can incorporate speed and power work"	3	7	−4
	7	Miscellaneous	"Developing speed and power is important"	3	10	−7

Table 4. *Cont.*

Physical, Fitness, and Injury Parameters	Rank	Theme	Exemplar Response	Percentage Coaches	Percentage Players	Percentage Difference
Volleyball-Specific Fitness	1	Specific Movement Development	"S&C improves jumping, running and arm swinging which are volleyball-specific movements"	37	27	10
	2	Improve Volleyball Performance	"Train specific muscles to enhance volleyball performance"	33	30	3
	3	Fitness	"Greater fitness increases the chances of winning"	20	0	20
	4	Injury Reduction	"Develop physical ability to reduce injuries"	13	0	13
	5	Positional Improvements	"Can specifically train the characteristics of different positions"	13	3	10
	6	Power/Speed	"Helps achieve higher, stronger and faster volleyball athletes"	10	40	−30
	7	Miscellaneous	"In Hong Kong, we have limited time to conduct S&C, due to court availability"	7	7	0
	8	Strength	"Muscular strength supports different types of movement, such as sudden changes of direction in competition"	7	10	−3
Injury Reduction	1	Strength	"Strengthening muscles supports the body through protecting joints"	60	27	33
	2	Stability/Postural Control	"S&C training can help enhance balance and motor control"	20	30	−10
	3	Injury Reduction	"Gets rid of injuries"	13	7	6
	4	Flexibility/Mobility	"Improves flexibility, which allows the joints to perform different movements"	10	0	10
	5	Fitness	"Adequate fitness levels are needed to perform skills and movements freely, and for preventing injuries"	7	23	−16
	6	Individualized Programming	"S&C can discover individual differences, which can be trained"	3	0	3
	7	Power	"Prevents problems, like the use of power in wrong postures"	3	10	−7
	8	Miscellaneous	"Injury is the enemy of athletes"	0	7	−7

Table 4. *Cont.*

Physical, Fitness, and Injury Parameters	Rank	Theme	Exemplar Response	Percentage Coaches	Percentage Players	Percentage Difference
Injury Rehabilitation/ Return to Play	1	Enhanced Recovery	"S&C training can speed up recovery and help players adapt to training demands"	47	43	4
	2	Strength	"Muscles atrophy and regress during injury, therefore need to be strengthened"	33	47	−14
	3	Decrease Re-Injury Risk	"It is easy to get injured once returning to training, so S&C helps overcome this"	23	10	13
	4	Accelerate Return to Play	"The most important thing for players is the time to get back on the court. The knowledge and technology nowadays speeds up this process"	20	17	3
	5	Flexibility/Mobility	"Provides an opportunity to improve flexibility that may have been a cause of injury"	6	7	−1
	6	Miscellaneous	"Depends on the level of injury"	0	7	−7

Some answers detailed more than one response, which was further sub-divided amongst the themes created.

Table 5. Preferred exercises of coaches and players for developing different physical, fitness and injury parameters.

Areas for Exercise Selection	Most Important Exercise	Exemplar Rationale for Exercise Selection	Percentage Coaches	Percentage Players	Percentage Difference
Strength	Squat and Variations	"Squatting increases leg muscle strength, leading to improved jumping and explosiveness"	52	60	−8
	Bench Press/Push Up	"Shoulder strength for volleyball performance improvement"	11	8	3
	Lunge and Variations	"Strengthening the leg muscles"	11	4	7
	Core (e.g., Plank)	"Whole-body is connected to the core, which affects movement coordination"	7	12	−5
	Miscellaneous (e.g., Interval Training)	"Interval training can cover different muscles simultaneously"	7	4	3
	Other (e.g., Burpee)	"Burpees train both strength and coordination"	7	4	3
	Pull Up	"A multi-joint exercise that increases upper body muscle strength"	4	8	−4

Table 5. *Cont.*

Areas for Exercise Selection	Most Important Exercise	Exemplar Rationale for Exercise Selection	Percentage Coaches	Percentage Players	Percentage Difference
Speed/ Power	Plyometrics (e.g., Continuous Jumping)	"Ability to produce explosive force in a short amount of time"	36	37	−1
	Sprint/Run	"Improve running performance over specific distances covered on the court"	25	7	18
	Burpees	"Involves most muscle groups in the body"	11	4	7
	Agility Ladder	"Can work a combination of speed and agility"	7	0	7
	Core (e.g., Cable Trunk Rotation)	"Abdomen is one of the most important muscle groups to train for volleyball"	7	4	3
	Miscellaneous (e.g., Timed Training)	"Timed training can simulate game situations"	7	11	−4
	Bench Press/Push Up	"Effective upper body power training"	4	11	−8
	Other (e.g., Deadlift)	"Deadlifts can focus on training power of the legs and back"	4	4	0
	Squat	"Similar movement to jumping which requires power"	0	11	−11
	Olympic Weightlifting	"Can load and improve the power of specific movements related to volleyball"	0	11	−11
Volleyball-Specific Fitness	Plyometrics (e.g., Medicine Ball Slam)	"Enhances movement speed and jumping ability"	29	29	0
	Squat	"Helpful for defensive postures and jumping ability"	18	14	4
	Core (e.g., Deadbug)	"Core is the central area for power production"	14	25	−11
	Other (e.g., Side Lunge)	"Side lunge action is similar to underhand pass"	11	4	7
	Miscellaneous (e.g., Weight Training)	"Weight training is required to make athletes strong and powerful"	11	7	4
	Volleyball Movement	"Lateral movement to ball receive can train the whole body and help physical fitness"	7	11	−4
	Bench Press/Push Up	"Strengthen the upper body, especially the shoulders"	7	7	0
	Deadlift	"Covers a lot of muscle groups useful for volleyball"	4	4	0

Table 5. *Cont.*

Areas for Exercise Selection	Most Important Exercise	Exemplar Rationale for Exercise Selection	Percentage Coaches	Percentage Players	Percentage Difference
Injury Reduction	Squat and Variations	"Reduces knee and ligament injuries"	38	19	20
	Flexibility/Mobility (e.g., Stretching)	"Improves joint range of motion and ability of muscle extension"	19	0	19
	Miscellaneous (e.g., Muscular Endurance)	"Muscle endurance is necessary. As we cannot determine the length of the game. Players need long-lasting physical ability"	19	3	16
	Core (e.g., Side Plank)	"Core exercises improve your balance and stability, which is important for reducing injuries"	12	19	−7
	Plyometrics (e.g., Box Landing)	"Improves how people land, which is how a lot of injuries occur"	8	37	−29
	Other (e.g., Nordics)	"Nordics help make the hamstrings resilient to injury"	4	14	−11
	Push Up	"Works the shoulders and arms, which are used a lot in volleyball"	0	8	−8
Volleyball Performance	Squat and Variations)	"Strengthens and supports joints for landing"	36	44	−8
	Plyometrics (e.g., Dumbbell Jump)	"Vertical jumping is required for blocking, serving, and spiking"	28	22	6
	Core (e.g., Plank)	"Core exercises like the plank can train the whole body"	12	11	1
	Other (e.g., Shuttle Runs)	"Shuttle runs are very important for chasing and going after the ball"	12	4	8
	Miscellaneous (e.g., Muscular Endurance)	"Volleyball players require repeated power, so muscular endurance should be trained"	8	0	8
	Deadlift	"All round exercise that should be performed"	4	4	0
	Push Up	"Important for spiking action"	0	7	−7
	Olympic Weightlifting	"Can develop an athlete to jump and land, while improving spiking and vertical blocking performance"	0	7	−7

Table 6. Coaches and players reported issues, disadvantages and desired improvements when implementing strength and conditioning.

	Rank	Theme	Exemplar Response	Percentage Coaches	Percentage Players	Percentage Difference
Issues	1	Time	"There is no regular physical training time"	60	20	40
	2	Facilities	"Very little facilities and space available"	30	13	17
	3	Equipment	"Lack of equipment in our venue"	17	20	−3
	4	Expertise	"We have limited knowledge regarding which exercises to do and how to do them"	17	30	−13
	5	Miscellaneous	"Difficult to maximize power in the gym room by yourself"	13	23	−10
Disadvantages	1	Increased Injury Risk	"Actions demonstrated maybe incorrect leading to more injuries"	27	7	20
	2	None	n/a	27	20	7
	3	Miscellaneous	"It is difficult to determine the upper limit of athletes"	23	17	7
	4	Overtraining/ Fatigue	"Unsure about how much training and recovery is required"	20	10	10
	5	Enjoyment	"Generally muscular strength and physical training will be dull"	10	27	−17
	6	Lack of Expertise	"It requires assistance from professionals and hiring an S&C coach is expensive"	0	7	−7
Desired Improvements	1	Periodization	"Specify the correct number of hours for the periodic physical training plan each week, including the exercises"	30	77	−47
	2	Education/ Consultation	"Enrol on S&C courses"	20	13	7
	3	Individualized Programming	"Before training perform detailed assessments of players, so programs can be created"	17	3	13
	4	Miscellaneous	"More sleep and eat together at lunchtime"	17	10	7
	5	S&C within Volleyball Training	"Integrate S&C into volleyball technical training"	10	0	10
	6	Flexibility/Mobility	"More warm-up, cool down and flexibility training"	0	10	−10

4. Discussion

To the authors' knowledge, this is the first study to address the practices and perspectives of volleyball coaches and players regarding S&C. A key finding from this survey is that coaches and players are the main individuals responsible for prescribing their S&C training (see Figure 2). Furthermore, coaches and players predominantly source their S&C information from peers within volleyball (e.g., head coach) (see Figure 1). However, this is problematic given that out of all participants, only one coach had an official S&C qualification and there was limited formal education in sports-related fields. Coaches and players mostly declared that S&C was required to develop volleyball skills, physical, fitness, and in-

jury parameters, emphasizing the demand for quality S&C training in volleyball. However, in Hong Kong there were a reported lack of S&C coaches available to work specifically in volleyball or the available finances to employ an S&C coach. Furthermore, other limitations, such as facilities, equipment and time, added to the difficulty in providing high-quality S&C provisions. This was further supported by only 10–20% of participants believing their current S&C practices were 'very effective', suggesting room for improvement.

Most coaches and players considered S&C training 'important' to 'very important' for all volleyball skills (see Table 1). For attacking based movements, spiking was seen as an area in which S&C could develop performance most, with power and speed being the primary objectives (see Table 3). Research in elite female volleyball players has demonstrated that a tailored S&C program can improve upper body strength (e.g., bench press, pullover) and power (e.g., medicine ball overhead throw) over a season [21]. However, these physical improvements were not transferred to volleyball-skill performance (i.e., jump spike speed) [21]. The variable most correlated with jump spike speed was standing spike speed, suggesting the importance of movement and velocity specificity when developing sports skills, which is sometimes difficult to achieve with S&C exercises [4,21,22]. This notion is supported through literature investigating the effects of an 8-week training program, consisting of three skill-based court sessions per week on skill and physical fitness parameters in volleyball players [23]. Results indicated no significant improvements in lower-body and upper-body muscular power, but spiking skill performance significantly improved, which included criteria of speed, accuracy, and technical competency [23]. For defensive based movements, blocking was considered an area where S&C could improve performance most, with jumping and blocking height the primary objectives (see Table 3). To improve jumping height, a key focus of S&C training in volleyball is likely to be plyometrics [8]. A recent systematic review including 15 studies demonstrated that plyometric training increases vertical and horizontal jump performance in volleyball players [8]. More specifically, two studies included in this review showed that a structured plyometric training program specifically improves two-foot, right-foot, left-foot, and side-step block jumps [24,25].

Almost all coaches and players believed S&C to be 'important' to 'very important' for developing strength, power, and speed (see Table 2). It is well established within the literature that an S&C program with an initial focus on strength development before training more power-based exercises (e.g., jumping) is beneficial in improving athletic ability [26]. To program and individualize such training within volleyball it has been suggested to develop a force-velocity profile of each player [27]. However, further evidence on how this approach influences the physical development of players and positively transfers to volleyball performance is required [27]. Encouragingly, it was also reported that S&C was considered 'important' to 'very important' for reducing injuries, rehabilitating injuries, and supporting players in their return to play (see Table 2). The most prevalent injuries in volleyball are acute ankle injuries and overuse injuries of the knee and shoulder [13,28]. A key area for reducing the likelihood of such injuries is to systematically monitor and modify volleyball training load and volume, which is a common role for S&C coaches, and ensures training and match-play stimuli are suitable for players [13]. Some coaches and players suggested S&C may lead to overtraining, fatigue, and increase injury prevalence (see Table 5). However, it is believed these participants considered S&C as an additional workload to existing skill-based training, as opposed to modifying workload to include S&C. To reduce volleyball-related injuries, players are encouraged to undertake a year-round S&C program, with a primary focus on eccentric exercises of the rotator cuff muscles, core strengthening, and stability training of the ankles, knees, and shoulders [13]. Accordingly, coaches and players also reported that strength and stability development were the primary means of S&C to reduce injuries (see Table 4).

For strength development, injury reduction, and volleyball performance, the most preferred exercises used by coaches and players was the squat and associated variations (see Table 5). This is similar to that reported by S&C coaches in other sports for strength and power development [15–17,29–34]. As various postures and movements in volleyball

require the adoption of a squat position (e.g., digging), it is highly recommended that players perform the squat, including associated variations (e.g., front squat, back squat, goblet squat), to improve strength and power capabilities [6]. Furthermore, it has been shown, in non-elite female volleyball players, that one-repetition maximum squat strength relative to body weight is very strongly correlated (r = 0.95) with vertical jump height, which has a positive transfer to different volleyball movements (e.g., blocking) [35]. The rationale of coaches and players for prescribing the squat was to develop lower body strength, jumping, and landing ability (i.e., stronger and more stable ankles, knees, and hips), which is in line with the aforementioned research recommendations. Coaches and players reported that plyometrics was the most commonly used exercise to develop speed, power, and volleyball-specific fitness (see Table 5). This again is similar to that prescribed by S&C coaches in other sports [15–17,29–34] and supported by contemporary research in volleyball, which suggests implementing plyometric exercises used for speed and power development into sport-specific practice [36]. The combination of plyometrics and skill-based volleyball activity has shown to simultaneously improve jumping ability and volleyball skills (e.g., throwing) [36]. However, the magnitude of improvement must consider the players' level. For example, if the player is elite and has high-level technical skills, it is likely the greatest improvements will be related to power and speed, as opposed to skill performance [36].

The main issues faced by coaches and players in this study regarding the implementation of S&C, were a lack of time, facilities, equipment, and S&C expertise available in Hong Kong (see Table 6). This demonstrates that S&C could be more comprehensive and widespread if local infrastructures enabled this in a more formalized manner. However, this is not uncommon even in professional sport. For example, strength and conditioning coaches working in cricket and soccer across various countries also stated that time was the biggest issue faced within their role, with a lack of facilities and equipment also being commonly reported [16,17]. In regards to expertise, there is limited formal or professional education and qualifications available in Hong Kong, which is a possible reason for the lack of practitioners. For example, only one coach held an S&C certification which was from the UK Strength and Conditioning Association (UKSCA). With this lack of education and perceived ability to prescribe S&C practices in mind, it is not entirely surprising the main disadvantage of S&C perceived by coaches was the potential to increase injury risk. Contrary to the beliefs of these coaches, studies have elucidated that when implemented appropriately, conducting strength training is safe [37,38]. It was reassuring to see that some coaches and players reported they wanted to develop their S&C knowledge and practical ability through further education and consultation with S&C professionals (see Table 5). The area that coaches and players perceived the greatest potential for improvement was periodization. This is in line with the reported time constraints and lack of access to facilities. Therefore making better use of the available time may be a viable strategy for greater integration of S&C into volleyball. Research suggests that programs adhering to strategic periodization strategies compared to non-periodized programs are superior for strength and power development, which are key components of volleyball performance [39,40].

5. Practical Applications

Coaches and players perceived S&C to be highly important for improving volleyball performance and reducing injuries. However, it was difficult to implement high-quality S&C practices, due to a lack of relevant expertise, time, facilities, and equipment. Although opportunities for professional development in S&C and particularly S&C in volleyball are limited in Hong Kong, coaches and players are advised to undertake related education and accreditations if possible. Alternatively, teams may consult with or employ a qualified S&C coach. This highlights the importance of professional S&C organizations providing overseas education and accreditation programs, to upskill and qualify those responsible for S&C delivery.

6. Limitations

This study surveyed 30 volleyball coaches and 30 players, and although this sample size is reasonable for this level of coach and player in Hong Kong, it may not be representative of all coaches and players within this demographic or extrapolated to those in other countries. Furthermore, due to the sample size, a sub-analysis comparing coaches and players across different ages or levels of competition was not possible. The required number of surveys required for valid analysis was not determined before data collection. However, it was aimed to obtain as many responses as possible within this purposive sample of coaches and players.

Supplementary Materials: Digital copies of the surveys used in this study can be found online at https://www.mdpi.com/2075-4663/9/2/28/s1.

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References

1. Seminati, E.; Alberto, A.E. Overuse in volleyball training/practice: A review on shoulder and spine-related injuries. *Eur. J. Sport Sci.* **2013**, *13*, 732–743. [CrossRef]
2. FIVB (Fédération Internationale de Volleyball): The Federation. Available online: https://www.fivb.com/en/thefivb/structure (accessed on 17 December 2020).
3. FIVB (Fédération Internationale de Volleyball): The Game. Available online: https://www.fivb.com/en/volleyball/thegame_glossary/basicvolleyballrules (accessed on 17 December 2020).
4. Hedrick, A. Training for High Level Performance in Women's Collegiate Volleyball: Part I Training Requirements. *Strength Cond J.* **2007**, *29*, 50–53. [CrossRef]
5. Marques, M.C.; van den Tillaar, R.; Vescovi, J.D.; González-Badillo, J.J. Changes in strength and power performance in elite senior female professional volleyball players during the in-season: A case study. *J Strength Cond. Res.* **2008**, *20*, 563–571. [CrossRef] [PubMed]
6. Holmberg, P.M. Weightlifting to improve volleyball performance. *Strength Cond. J.* **2013**, *36*, 79–88. [CrossRef]
7. Sánchez-Moreno, J.; Afonso, J.; Mesquita, J.; Ureña, A. Dynamics between playing activities and rest time in high-level men's volleyball. *Int. J. Perf. Anal. Sport.* **2016**, *16*, 317–331. [CrossRef]
8. Silva, A.F.; Clemente, F.M.; Lima, R.; Nikolaidis, P.T.; Rosemann, T.; Knechtle, B. The effect of plyometric training in volleyball players: A systematic review. *Int. J. Environ. Res. Public Health* **2019**, *16*, 2960. [CrossRef]
9. Marques, M.C.; van den Tillaar, R.; Gabbett, T.J.; Reis, V.M.; González-Badillo, J.J. Physical fitness qualities of professional volleyball players: Determination of positional differences. *J. Strength Cond. Res.* **2009**, *23*, 1106–1111. [CrossRef]
10. Bunn, J.A.; Ryan, G.A.; Button, G.R.; Zhang, S. Evaluation of strength and conditioning measures with game success in division I collegiate volleyball: A retrospective study. *J Strength Cond. Res.* **2020**, *34*, 183–191. [CrossRef] [PubMed]
11. Bere, T.; Kruczynski, J.; Veintimilla, N.; Hamu, Y.; Bahr, R. Injury risk is low among world-class volleyball players: 4-year data from the FIVB Injury Surveillance System. *Brit. J. Sports Med.* **2015**, *49*, 1132–1137. [CrossRef]
12. Eerkes, K. Volleyball Injuries. *Curr. Sports Med. Rep.* **2012**, *11*, 251–256. [CrossRef]
13. Reeser, J.C.; Verhagen, E.; Briner, W.W.; Askeland, T.I.; Bahr, R. Strategies for the prevention of volleyball related injuries. *Brit. J. Sports Med.* **2006**, *40*, 594–600. [CrossRef] [PubMed]
14. Marques, M.C.; González-Badillo, J.J.; Kluka, D. In-season resistance training for professional male volleyball players. *Strength Cond. J.* **2006**, *28*, 16. [CrossRef]
15. Weldon, A.; Duncan, M.J.; Turner, A.; LaPlaca, D.; Sampaio, J.; Christie, C.J. Practices of strength and conditioning coaches: A snapshot from different sports, countries and expertise levels. *J. Strength Cond. Res.* **2020**. [CrossRef]

16. Weldon, A.; Duncan, M.J.; Turner, A.; Sampaio, J.; Noon, M.; Wong, D.; Lai, V.W. Contemporary practices of strength and conditioning coaches in professional soccer. *Biol. Sport* **2020**. [CrossRef]
17. Weldon, A.; Duncan, M.J.; Turner, A.; Christie, C.J.; Pang, C.M. Practices of strength and conditioning coaches in professional cricket. *Int. J. Sports Sci. Coach.* **2020**. [CrossRef]
18. Braun, V.; Clarke, V. Using thematic analysis in psychology. *Qual. Res. Psychol.* **2006**, *3*, 77–101. [CrossRef]
19. Crowley, E.; Harrison, A.J.; Lyons, M. Dry-Land resistance training practices of elite swimming strength and conditioning coaches. *J. Strength Cond. Res.* **2018**, *32*, 2592–2600. [CrossRef]
20. Healy, R.; Kenny, I.C.; Harrison, A.J. Resistance training practices of sprint coaches. *J. Strength Cond. Res.* **2016**. [CrossRef]
21. Valades, D.; Palao, J.; Aúnsolo, Á.; Ureña, A. Correlation between ball speed of the spike and the strength condition of a professional women's volleyball team during the season. *Kinesiology* **2016**, *48*, 87–94. [CrossRef]
22. Cronin, J.; McNair, P.J.; Marshall, R.N. Velocity specificity, combination training and sport specific tasks. *J. Sci. Med. Sport.* **2001**, *4*, 169–178. [CrossRef]
23. Gabbett, T.; Georgieff, B.; Anderson, S.; Cotton, B.; Savovic, D.; Nicholson, L. Changes in skill and physical fitness following training in talented-identified volleyball players. *J. Strength Cond. Res.* **2006**, *20*, 29–35. [PubMed]
24. Milic, V.; Nejic, D.; Kostic, R. The effect of plyometric training on the explosive strength of leg muscles of volleyball players on single foot and two-foot takeoff jumps. *Facta Univ. Ser. Phys. Educ. Sport.* **2008**, *6*, 169–179.
25. Trajkovic, N.; Kristicevic, T.; Baic, M. Effects of plyometric training on sport-specific tests in female volleyball players. *Acta Kinesiol.* **2016**, *10*, 20–24.
26. Suchomel, T.J.; Nimphius, S.; Bellon, C.R.; Stone, M.H. The importance of muscular strength: Training considerations. *Sports Med.* **2018**, *48*, 765–785. [CrossRef] [PubMed]
27. Petridis, L.; Palinkas, G.; Troznai, Z.; Béres, B.; Utczás, K. Determining strength training needs using the force-velocity profile of elite female handball and volleyball players. *Int. J. Sports Sci. Coach.* **2020**. [CrossRef]
28. Kilic, O.; Maas, M.; Verhagen, E.; Zwerver, J.; Gouttebarge, V. Incidence, etiology and prevention of musculoskeletal injuries in volleyball: A systematic review of the literature. *Eur. J. Sport Sci.* **2017**. [CrossRef]
29. Ebben, W.P.; Blackard, D.O. Strength and conditioning practices of National Football League strength and conditioning coaches. *J. Strength Cond. Res.* **2001**, *15*, 48–58.
30. Ebben, W.P.; Carrol, R.M.; Simenz, C.J. Strength and conditioning practices of National Hockey League strength and conditioning coaches. *J. Strength Cond. Res.* **2004**, *18*, 889–897.
31. Ebben, W.P.; Hintz, M.J.; Simenz, C.J. Strength and conditioning practices of Major League Baseball strength and conditioning coaches. *J. Strength Cond. Res.* **2005**, *19*, 538–546.
32. Far Saeed, J.; Bahman, M.; Arsalan, D. Strength and conditioning practices of Iran wrestling league strength and conditioning coaches. *Pedagog. Psych Med. Biol. Probl. Phys. Train Sports.* **2014**, *18*, 34–45.
33. Jones, T.W.; Smith, A.; Macnaughton, L.S.; French, D.N. Strength and conditioning and concurrent training practices in elite rugby union. *J Strength Cond. Res.* **2016**, *30*, 3354–3366. [CrossRef] [PubMed]
34. Simenz, C.J.; Dugan, C.A.; Ebben, W.P. Strength and conditioning practices of National Basketball Association strength and conditioning coaches. *J Strength Cond. Res.* **2005**, *19*, 495–504. [PubMed]
35. Augustsson, S.R. Maximum strength in squats determines jumping height in young female volleyball players. *Open Sports Sci. J.* **2013**, *6*, 41–46. [CrossRef]
36. Gjinovci, B.; Idrizovic, K.; Uljevic, O.; Sekulic, D. Plyometric training improves sprinting, jumping and throwing capacities of high level female volleyball players better than skill-based conditioning. *J. Sports Sci. Med.* **2017**, *16*, 527–535.
37. Butragueno, J.; Benito, P.J.; Maffuli, N. Injuries in strength training: Review and practical application. *Eur. J. Hum. Movement* **2014**, *32*, 29–47.
38. Lavellee, M.E.; Tucker, B. An overview of strength training injuries: Acute and chronic. *Curr. Sports Med. Rep.* **2010**, *9*, 307–313. [CrossRef] [PubMed]
39. Bompa, T.O.; Buzzichelli, C. *Periodization: Theory and Methodology of Training*, 6th ed.; Human Kinetics: Champaign, IL, USA, 2017.
40. Harries, S.K.; Lubans, D.R.; Callister, R. Systematic review and meta-analysis of linear and undulating periodized resistance training programs on muscular strength. *J. Strength Cond. Res.* **2015**, *29*, 1113–1125. [CrossRef]

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Practices of strength and conditioning coaches in Brazilian elite soccer

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ABSTRACT: Brazil is the leading global exporter of soccer players, with approximately 2,000 international transfers to different clubs per year. Although Brazilian players compete in the most prestigious soccer leagues worldwide, the habitual training methods, strategies, and routines of Brazilian soccer strength and conditioning coaches (SCCs) are undocumented. This study used a standard online survey to collect and characterize the strength and conditioning practices of Brazilian soccer SCCs. Forty-nine SCCs (age: 40.4 ± 7.5 years; professional experience: 15.3 ± 7.5 years) working in Brazilian professional soccer teams participated in this study. The survey consisted of eight sections: 1) background information; 2) muscular strength-power development; 3) speed training; 4) plyometrics; 5) flexibility training; 6) physical testing; 7) technology use; and 8) programing. Results indicated that training and testing practices of Brazilian SCCs are strongly affected by the congested fixture schedules, extensive traveling distances, and socio-economic disparities between different regions of the country. We describe all these different strategies and methods in detail, providing a comprehensive view and a critical examination of Brazilian soccer strength and conditioning practices. Brazilian SCCs and professional soccer organizations can use the findings from this study to develop training strategies and customize education programs. Practitioners from other countries can use this information to design training programs closely tailored to the background of Brazilian athletes, which may support their adaptation to different competitive scenarios and game demands, such as those found in the most important soccer leagues worldwide.

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