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

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ABSTRACT

This study describes the practices of strength and conditioning coaches (SCCs) from different sports, countries and expertise levels. One-hundred and 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 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) 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 94% of SCCs. The hang clean (82%), power clean (76%), and clean high pull (63%) were the most commonly prescribed Olympic Weightlifting exercises. Multiple hops/lunges (84%) were the most commonly prescribed plyometrics exercises. For open ended questions, 40% of SCCs wanted to integrate more technology into their programs, whereas, 30% of coaches believed technology will be the main future trend in strength and conditioning. SCCs from different sports, countries and expertise levels can use the information presented in this study to review

their current practices and potentially provide a source of new ideas for diversifying or modifying future practices too.

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

INTRODUCTION

A strength and conditioning coach (SCC) forms part of a multidisciplinary team and is required to have a general understanding of coaching and sports science with the primary roles of reducing injuries and improving performance (43). As strength and conditioning continues to evolve and additional responsibilities are given to SCCs, it is important to understand the current practices of SCCs in a range of sports, countries and expertise levels, to identify and recognize possible gaps between theoretical models, proposed guidelines and real practice, and to further develop research and education resources in this field. Strength and conditioning practices have been examined in some sports such as National Football League (NFL) (11), National Hockey League (NHL) (12), Major League Baseball (MLB) (13), National Basketball Association (NBA) (37), rowing (17), wrestling (14), rugby union (21), and swimming (7), and populations such as high school strength and conditioning coaches (10), cricket coaches (30), strongman athletes (44), sprint coaches (20) and rugby union coaches (33). Although these studies provide rich data on the practices of SCCs, there are still a number of sports, countries and levels underrepresented, which it would be beneficial to add such data to this field of research.

The aforementioned research also provides valuable insight for understanding the physical testing, exercise prescription, and programming strategies used by SCCs. Physical testing is well established within SCCs practice as an effective way to guide training for both

competitive and non-competitive sports (Peterson, 2018). In prior surveys physical testing was reported as being commonly used in NFL (11), NHL (12), MLB (13), NBA (37), wrestling (14), rowing (17), and rugby union (21). As might be expected, there is considerable commonality in the physical constructs assessed by SCCs with body composition (11-13,17, 21,37), strength (11,13-14,17,37), and power (12,14,17,21,37) being assessed regularly across sports. Acceleration and speed appeared to be tested infrequently by less than 50% of SCCs in NFL (11), NHL (12) and MLB (13), irrespective of the importance of these physical attributes in these sports. Whereas, cardiovascular endurance was tested with regularity in the NFL (11), NHL (12), rowing (17), and rugby union (21), but only in rowing was it assessed by more than 90% of SCCs. Flexibility was cited as being tested in NFL (11), MLB (13), and rowing (17), whereas the proportion of coaches testing this construct was less than 50%. Oher physical testing components such as anaerobic capacity (12,14) muscular endurance (12,14) and agility (14,37) have been used frequently in some sports but not all. In general SCCs in MLB (13) reported less use of physical testing, and tested fewer constructs than other sports such as NFL (11), NHL (12), and NBA (37). Therefore, although physical testing is commonly used by SCCs in elite sport as demonstrated in previous surveys, it is also of interest to ascertain whether such practices are also commonplace in different sports and levels of expertise.

Regarding exercise prescription, SCCs considered the squat to be the most important exercise for strength and power development, in numerous sports: swimming (7), NFL (11), NHL (12), MLB (13), wrestling (14), rugby union (21), and NBA (37). Olympic Weightlifting and associated derivatives were also frequently prescribed in the NBA (37) (95%), NHL (12) (91%), NFL (11) (88%), rowing (17) (87%), and wrestling (14) (66%). Plyometrics was frequently prescribed for power development in NBA (Simenz, 2005) (37), wrestling (14) (100%), rugby union (21) (95%), MLB (13) (95%), NHL (12) (91%), and NFL (11) (73%). Whereas, speed development exercises were commonly prescribed in NFL (11) (100%), MLB

(13) (100%), wrestling (14) (100%), NHL (12) (96%), rugby union (21) (93%), and NBA (37) (80%). While there is some commonality in the types of exercises prescribed by SCCs, given a general need to train all components of fitness, there are naturally differences where SSCs must tailor the training to the demands of their sport. For example, in the MLB (13) it was deemed important to prescribe exercises to particularly focus on the development and function of the rotator cuff/shoulder stabilizer, which is logical given the importance of pitching in MLB, however, this was not an explicit focus of strength exercises prescribed by SCCs in other sports (11,14,17,21,37). The reasons for discrepancies in other sports are less clear, for example, SCCs in wrestling (14) and rowing (17) favored lower body plyometric exercises, whereas, it may be argued that upper body plyometric exercises are just as important to develop the physical capacities specific to these sports. It is therefore acknowledged that there are some commonalities in the types of exercises prescribed by SCCs across most sports, albeit prescribed with different frequencies, whereas, to meet the physical demands in some sports (e.g., baseball), SCCs may also prescribe specific exercises.

Previous studies assessing the practices of SCCs, have predominantly focused on North American sports (11-13,37), and that of the elite level (7,11-14,17,21,37). However, as the discipline of strength and conditioning continues to grow, which is evident from the National Strength and Conditioning Association (NSCA) now expanding to 45,000 members across 72 countries (27), there is a need to develop a broader understanding of the practices of SCCs. Furthermore, with the advances in strength and conditioning research and the development of technology software and hardware (25), it is also important to ascertain if SCCs are able to keep up to date with contemporary practices in strength and conditioning.

Therefore, the purpose of this study was to build on the current body of research and provide further insight and description into the practices of SCCs of different sports, countries and expertise levels. Furthermore, this study aimed to provide a source of information for SCCs

to review their current practices and potentially provide a source of new ideas for diversifying or modifying future practices too.

METHODS

Experimental Approach to the Problem

This cross-sectional explorative study was designed to provide descriptive information about the practices of SCCs from a range of sports, countries, and expertise levels. The survey was adapted from previous research (11,21) and developed using open access survey administration application Google Forms. The survey comprised of eight sections: (a) background information, (b) muscular strength and power development, (c) speed development, (d) plyometrics, (e) flexibility development, (f) physical testing and (g) technology use, and (h) programming and any additional comments (Appendix 1). The first seven sections included 36 fixed response questions, and respondents had the opportunity to provide specific answers using the "other" option, and the last section included four open-ended questions. Some questions allowed respondents to select more than one response (e.g., which sport(s) do you currently coach), therefore some completed questions have more responses than others. Pilot testing was conducted by the six members of the research team, then by six accredited SCCs, for a total three rounds of pilot testing before the survey was finalized. Pilot testing led to slight modifications to the wording and structure of the survey to ensure its validity for use with this population. The survey was circulated via commonly used social media platforms: LinkedIn, Twitter and Instagram, frequently used by those working in strength and conditioning. This approach was used to provide a broad overview of the range of different perspectives of SCCs rather than capturing a specific subset of SCCs as has been the case in prior studies.

Subjects

One-hundred and fifty-six SCCs participated in this study, comprising of 143 males (92%) and 13 females (8%). The study was approved by the Research Ethics Committee of the Technological and Higher Education Institute of Hong Kong. Inclusion criteria were those currently employed as a SCC. All subjects were informed of the benefits and risks of the study before providing informed consent to initiate the survey online. The survey was anonymous, and all questions required an answer, therefore, only fully completed surveys were used for analyses. The start of the survey included an explanation of the purpose, aims, time-commitment required, and the confidentiality of information. Respondents were informed that a copy of results may be sent to them upon request.

Statistical Analyses

All responses from the Google Forms were downloaded into an Excel 2016 spread-sheet (Microsoft Corporation, Redmond, WA). Fixed response questions were assessed using a frequency analysis. A six-stage thematic analysis (3) approach was used to assess open-ended questions to determine responses to programming and additional comments provided by respondents, including: (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 by studies surveying SCCs and sports coaches (7,20). Using this approach, overarching clear and identifiably distinct themes, representing the main ideas or patterns emerging from the raw data were generated for each of the open-ended questions. In some cases responses received from SCCs provided sufficient information that more than one overarching theme could be identified.

RESULTS

Background Information

A total of 156 SCCs with a mean strength and conditioning experience of 8.35 ± 6.89 years, participated in this study. Responses were received from 17 countries, with the most commonly reported being: United States of America (33%), United Kingdom (21%), China (18%) and Spain (12%). A total of 48 sports were reported as being worked in (Figure 1), whereas 54% of SCCs concurrently worked in more than one sport.

Strength and conditioning related certifications were held by 71% of respondents, whereas 23% of these had more than one qualification. The most commonly reported strength and conditioning related certifications were: NSCA Certified Strength and Conditioning Specialist (CSCS) (70%), UKSCA Accredited Strength and Conditioning Coach (ASCC) (14%), ASCA Strength and Conditioning Coach accreditation (13%), CSCCa Strength and Conditioning Coach Certified (SCCC) (11%), and USAW United States of America Weightlifting Certification (9%). In total, 99% of SCCs reported being educated to degree level, whereas 94% of these reported completing a degree in a sports science related field. The most commonly reported highest level of degree were: Bachelor's degree (22%), Master's degree (66%), and PhD (8%). A strength and conditioning related internship was completed by 69% of respondents, and the most commonly reported times for completing an internship were: before certification (69%), during certification (46%) and after certification (27%). The level of athlete(s) the SCCs currently work with are presented in Figure 2.

Insert Figure 1 and 2 about here

Muscular Strength and Power Development

Off-Season: The most commonly reported number of strength training sessions during this period per athlete/team each week were: 3 sessions (39%), 2 sessions (21%), 4 sessions (17%), and 5 sessions (8%). The most commonly reported length of sessions were: 45-60 minutes (50%), 60-75 minutes (28%), 30-45 minutes (12%), and 75-90 minutes (8%). The most commonly reported set ranges were: 3-4 (60%), and 5-6 (22%). Ten (6%) SCCs provided other responses including: "dependent on the objectives" and "individualized for each athlete". The most commonly reported repetition ranges were: 4-6 (31%), 10-12 (31%), and 7-9 (21%). Eleven (7%) SCCs provided other responses including: "I use an auto-regulatory progressive resistance exercise protocol on main lifts" and "Depends on the periodization, sometimes using 1x20 method, but a usual rep range 10-15".

In-Season: The most commonly reported number of strength training sessions during this period per athlete/team each week were: 2 sessions (51%), 3 sessions (25%), 4 sessions (9%), and 1 session (6%). The most commonly reported length of sessions were: 45-60 minutes (40%), 30-45 minutes (32%), 60-75 minutes (14%), and 15-30 minutes (8%). The most commonly reported set ranges used were: 3-4 (76%), and 5-6 (11%). Five (3%) SCCs provided other responses, including: "depends what stage of development" and "depends on sport". The most commonly reported repetition ranges used were: 4-6 (49%), 1-3 (18%), and 7-9 (18%). Seven (4%) SCCs provided other responses, including: "Athlete dependent" and "2-3 reps for multi-joint, explosive movements; 4-6 reps for auxiliary, strength-based movements".

Periodization, Set Loads and Recovery: Periodization strategies were used by 96% of respondents to structure their programs. The most commonly reported methods for determining set loads were: ratings of perceived exertion (RPE) (49%), repetition maximum (45%), predicted repetition maximum (42%), athlete determined (33%), velocity (e.g., accelerometer) (31%), trial and error (17%), subjective/guess (14%), and train to failure (5%). The amount of

recovery time prescribed by SCCs between strength and conditioning training, sports practice and competition is presented in Table 1.

Resistance Training: All SCCs reported using resistance type training, and aside from the more traditional exercises, whereby the concentric portion of the lift is emphasized, SCCs also reported using eccentric (92%), isometric (73%), variable (e.g., bands and chains) (69%), machine (19%), and isoinertial (e.g., flywheel) (10%) modes of resistance. Olympic Weightlifting and associated derivative exercises were prescribed by 87% of respondents, and an overview of the prescribed Olympic Weightlifting exercises are presented in Figure 3.

Insert Table 1 and Figure 3 about here

Speed Development

Speed development exercises were prescribed by 99% of SCCs, and an overview of the exercises prescribed are presented in Figure 4.

Insert Figure 4 about here

Plyometrics

All SCCs coaches reported using plyometric exercises, an overview of the purposes for prescribing plyometric exercises are presented in Figure 5. Eight (5%) SCCs stated “injury prevention” as another purpose for using plyometrics that was not available in the multiple choice answers for this question. The most commonly reported times for prescribing plyometric exercises were: before weights (40%), as complex training (35%), on separate days (15%), and after weights (5%). The most commonly reported times of year for prescribing plyometric exercises were: all year round (66%), pre-season (26%), in-season (26%), training

camp (10%), and off-season (8%). The plyometric exercises prescribed by SCCs are presented in Figure 7.

Insert Figure 5 and 6 about here

Flexibility Development

Flexibility exercises were prescribed by 99% of respondents, and an overview of the most commonly reported times for prescribing flexibility exercises are presented in Figure 7. The most commonly reported length of flexibility sessions were: 5-10 minutes (41%), 10-15 minutes (30%), ≥20 minutes (30%), 0-5 minutes (11%), and 15-20 minutes (10%). An overview of the frequency that SCCs prescribe different methods of flexibility exercises are presented in Table 2. The most commonly reported duration of holding static stretches were: ≥ 20 seconds (30%), 10-15 seconds (23%), 15-20 seconds (21%), and 5-10 seconds (8%).

Insert figure 7 and Table 2 about here

Physical Testing and Technology Use

Physically testing athletes was reported as being administered by 94% of respondents, with the most commonly reported times for administering physical tests being: all year round (54%), pre-season (46%), off-season (30%), in-season (18%), and training camp (10%). An overview of the most commonly reported physical tests are presented in Figure 8.

Technology-based equipment was reported as being used by 65% of respondents, and 22% of these provided specifically which equipment was used, being: jump mat/other jump assessment devices (55%), bar velocity trackers (41%), speed gates (23%), global positioning system (GPS) (14%), force plates (14%), mobile applications (9%), heart rate monitors (4.5%),

video analysis software (4.5%), crane scales for isometric mid-thigh pull (4.5%), and body composition analyzers (4.5%).

Athlete wellbeing was reported as being monitored by 84% of respondents, with the most common methods used being; mobile device questionnaires (50%), verbal questionnaires (47%), and written questionnaires (32%). In total 9% of those monitoring athlete wellbeing provided other responses, including: conversation/talking with athletes (83%), and monitoring training performance (17%).

Insert Figure 8 about here

Programming and Additional Comments

Four open-ended questions were asked in the final section of the survey (see Appendix 1), to allow more detailed responses from SCCs. From the responses to these questions higher order themes were created. The number of responses to each theme and exemplar responses are provided in Tables 3-5.

The final open-ended question provided SCCs the opportunity to make any additional comments, which 9% did. The responses are summarized here: “I’m in charge of both male and female squads, so it’s quite crazy and hard to manage and individualize training for that number of athletes”, “Time for planning and programming barely exists”, “Good strength and conditioning is not about performance enhancement; it is about optimizing movement patterns while pursuing adaptation goals”, “For this industry to grow, the current certification process has to be integrated within the university’s sports science/human movement/exercise science curriculum, and more research should be done to uncover the black box of force production”, and “This survey will provide valuable cross-sectional information, but we also need to think how to obtain longitudinal or time-related information”.

Insert Table 3, 4 and 5 about here

DISCUSSION

This study sought to describe the practices of SCCs from a wide range of sports, countries and expertise levels. Unlike other studies, this survey included responses from soccer (45%), track and field (30%), volleyball (23%), golf (17%) and tennis (17%), which had similar response rates to previous research on specific sports (n = 20-43) (7,11-13,17,20,21,30,34,37). As the use of strength and conditioning is widespread in popular sports such as soccer, and there is an expectation of SCCs to implement research informed practices, it is important the current practices of SCCs are further investigated to build upon the limited evidence and understanding we have in some sports (38,42). Results indicated 54% of SCCs worked in more than one sport, which was apparent across all experience, qualification and expertise levels. This number is possibly inflated by the proportion of coaches working within university/college (55%) and high school/senior school (20%) populations, often requiring SCCs to work across a range of sports. Nevertheless, this raises the importance of SCCs having a broad understanding of the application of strength and conditioning in different sports, recognizing general and specific principles of training and possible transferences between sports.

In regards to academic qualifications, the highest qualification held by SCCs were a master's degree (65%), bachelor's degree (25%), PhD (8%), and post-graduate certificate (0.6%), of which 94% were in a sports science related field. Furthermore, 71% of SCCs had a strength and conditioning related certification or accreditation. This is encouraging for the profession and how associated higher education curriculums around the world are seemingly addressing areas of strength and conditioning. To note, the survey used in this study was designed to enable all expertise levels to share their practices irrespective of qualification or

experience level. It has been evidenced that competent and expert SCCs share similar skills, knowledge and experiences, whereas, the main differentiating factor, is that expert SCCs have built upon these foundational characteristics, to develop a higher level of coaching expertise (23). Whereas, interestingly irrespective of expertise level or experience a number of SCCs reported the most unique aspect of their strength and conditioning program was they "focused on the basics" (see Table 3). Given this study and prior studies have focused predominantly on reporting cross-sectional data, investigating the development of SCCs and their practices longitudinally would provide further valuable evidence and understanding to this field.

New information is provided by this study on strength and conditioning internships, where 107 (69%) SCCs completed an internship, which were predominantly before obtaining a strength and conditioning related certification (69%), therefore it may be suggested internships were completed when SCCs had less experience. Similar findings were observed in a large survey of 600 SCC interns, that shown 58-59% were $\leq$ 25 years old and had $\leq$ 2 years' experience (38). The high number of internships completed may suggest the importance SCCs place on this type of learning experience, which allows them to apply their strength and conditioning knowledge and practical skills (9). Furthermore, it has been observed that completing internships can increase the likelihood of employment, as established in the aforementioned survey of 600 SCC interns, that found 44% of SCC interns obtained employment with the organizations offering the internship (38).

With regard to strength and power development, results indicated a slight reduction in training load in-season as one less strength and conditioning session per week was completed, which may suggest an intentional reduction. Similar findings were observed in SCCs surveyed in rugby union, which concluded the reduction maybe associated with a maintenance approach in-season, whereas SCCs have more contact time with athletes to develop the physical qualities required in their given sports during the off-season (21). The use of maintenance sessions in-

season can be beneficial in sports such as soccer, where a single strength and conditioning maintenance session used in-season over a 12-week period was sufficient in maintaining strength and power gains achieved during a preceding developmental period (35).

Periodization strategies were used by 97% of SCCs, similar to previous surveys in wrestling (14) (100%), rowing (17) (97%), NBA (37) (91%), NHL (12) (90%), rugby union (21) (90%), MLB (13) (83%), and NFL (11) (69%). This also aligns with research recommendations that has shown superior training adaptations in periodized training programs compared to those non-periodized, across different ages, training statuses and program lengths (31). Although the most commonly used method for determining set loads was RPE (49%), a number of SCCs still subjectively guessed (14%), meaning a load was estimated using no systematic method, however this deviates from research informed recommendations for planning resistance training programs, where it is deemed important to methodically estimate set loads and volumes in order to prescribe a suitable resistance and elicit the desired athlete responses and adaptations (18). It may be speculated that coaches use a method of subjectively guessing set loading due to time constraints or possibly having a strong understanding of the ability level of their athletes, which may still be suitable for athlete development.

Regular physical testing of athletes was reported by 94% of SCCs, with an average of 5.7 aspects of fitness tested, and the most common tests used were for muscular strength (85%), similar to previous surveys in: NHL (12) (100%), wrestling (14) (97%), rugby union (21) (84%), and NBA (37) (75%). It is unsurprising that muscular strength was the most commonly reported test, as developing strength in both adolescent and adult populations is associated with reduced injury rates and is important for establishing a foundation for developing other attributes such as speed and power (39). Additionally, 84% of SCCs reported monitoring athlete wellbeing, with the most common methods used being self-reporting techniques, such as mobile device questionnaires (50%). The use of self-reporting techniques is a valid method

for monitoring athletes' fatigue and wellbeing levels, and sports coaches and SCCs can use this information to modify set loads, training intensity, training volume and/or provide further athlete support (36). Similarly, within training sessions SCCs primarily reported using subjective measures such as RPE (49%) for determining set loads, which has shown to also be a valid and reliable tool (r = 0.8 – 0.9) to inform SCCs whether modifications are required for exercise prescription, set load and/or intensity (6). Therefore, it may be implied the SCCs surveyed physically test and monitor athlete's wellbeing in line with other sports and research recommendations.

The current study included questions regarding the integration of technology-based equipment into strength and conditioning training programs, which is of importance given its continued growth and application into all levels of sport (25). In total 65% of SCCs reported using technology-based equipment, which additional comments from SCCs revealed jump assessment devices (n = 12) were frequently used. This seems rational given all SCCs prescribed plyometrics, 84% prescribed plyometrics for lower body power, and 74% physically tested muscular power, in which jump assessment devices may be used to ascertain whether training programs provided the specific physical adaptations desired for the athlete. The survey received open-ended responses from some SCCs on the use of mobile device applications for monitoring and testing athletes, which nowadays there are affordable and commercially available applications to accurately assess jumping performance (19), however this was not specifically surveyed, therefore it cannot be suggested such applications were being used. Furthermore, responses to open-ended questions (see Table 4-5) revealed 40% of SCCs reported technology being something they would add to their programs with the predominant focus of testing and monitoring athletes, whereas 30% of SCCs believed it will also be an area that will become increasingly important in the future of strength and conditioning (30%).

Therefore, given the development and integration of technology, this may become more of a focus in future research surveying practices of SCCs.

In regards to training load and recovery between sessions, it was observed most SCCs planned strength and conditioning and sports training sessions on the same day, irrespective of the focus of training (speed, strength and power). Whereas, 48hrs recovery was most commonly prescribed between strength and conditioning sessions and competition, which suggests SCCs provided additional time for athletes to fully recover. The recovery duration provided to athletes is highly dependent on the type and intensity of the physical activity being performed, whereas it is imperative athletes receive adequate recovery from physical training prior to sports competition to ensure they can perform optimally (1,4). As observed multiple sessions may occur in the same day, whereas, it is advised that if sessions are focusing on opposing physical qualities and performed within a short time frame this may hinder neuromuscular and aerobic adaptations, therefore, a minimum of six hours recovery should be provided between sessions for concurrent training practices (33). However, the specific duration of recovery between sessions and physical characteristics of the competition being undertaken was not explicitly investigated in this study.

This study surveyed the type of resistance training exercises prescribed, which found concentric and eccentric type training were the most common. In a survey on the strength and conditioning practices of university and high school cricket coaches, it was observed only 1 out of 15 reported using eccentric training for injury prevention (30), which is surprising considering eccentric training has been shown to reduce injuries in cricket players (15). It was suggested the lack of strength and conditioning education of coaches may be an underlying factor for such practice (30). Therefore, it may be suggested the SCCs in this study had a deeper understanding of strength and conditioning principles and used a more comprehensive approach to prescribe resistance training exercises (e.g., types of contraction), in order to

develop the physical qualities of athletes and reduce the likelihood of injury (41). However, it must be noted in this study the question for types of resistance training used was more general in nature compared to Pote's study which was regarding injury prevention.

Olympic Weightlifting and associated derivatives were prescribed by 87% of SCCs, similar to that reported in NBA (37) (95%), NHL (12) (91%), rugby union (21) (90%), NFL (11) (88%), rowing (17) (87%) and wrestling (14) (83%), whereas, the most commonly prescribed exercises in this study were the hang clean, power clean and clean high-pull. It is surprising the limited prescription of the snatch and snatch derivatives, given it has been shown hang cleans and hang snatches provide similar improvements in athletes power, strength and speed (2). Whereas, it is recommended that Olympic Weightlifting movements must be performed safely and with good technique, where the use of derivatives such as the clean high-pull can be just as effective in improving athletic development such as triple extension, when performed with maximal intent (40). Therefore, it may be speculated that SCCs in this study predominantly used the clean and clean derivatives for simplicity and safety, while not impeding athletic development.

Speed development training was prescribed by 99% of SCCs, similar to that reported in NFL (11), MLB (13), NBA (37) and wrestling (14) (100%), NHL (12) (96%) and rugby union (21) (93%). The most commonly prescribed exercises for speed development were: plyometrics (90%), strength training (78%), resisted running (63%) and sport specific movements (56%), indicating SCCs used a range of exercises along the force-velocity continuum, which is important to comprehensively develop the force-velocity characteristics of athletes (40,45). Furthermore, using a combination of plyometrics and sport-specific movements has been recommended to transfer physical adaptations (e.g., speed development) to sports performance (8,32).

All SCCs reported programming plyometric exercises which were predominantly prescribed all year round (66%), similar to previous surveys in NHL (12), NBA (37), wrestling (14) and rugby union (21). Whereas, plyometrics were mostly prescribed before weights (40%) and as complex training (35%), which is in line with research on power development (24). It has been recommended using complex training for power development, where the short-term intrasession gains in power derive from post activation potentiation, whereas programming complex training within a training cycle has also shown increases in lower body power metrics such as peak ground reaction force during a countermovement jump (24,26). It should be noted that increases in lower body power have not shown to differ significantly from when plyometrics and resistance training were performed separately, but complex training may be a more time efficient option for SCCs to implement in their program (22,24,26). The most commonly prescribed plyometric exercise in this study was multiple hops/lunges (84%). Similarly, in a survey on high school SCCs working across multiple sports also found multiple hops/lunges (89%) to be the most commonly prescribed (10). From previous surveys on specific sports, there was no single plyometric exercise most commonly prescribed: box drills in NHL (12) (100%), upper body plyometrics in NBA (37) (100%), jumps in place in MLB (13) (90%), multiple hops and bounding in NFL (11) (both 89%), jumps in place in wrestling (14) (82%), jumps in place in rowing (17) (75%), multiple hops, box drills and jumps in place in rugby union (21) (all 78%). This may indicate sport-specific or preferential plyometric exercises being prescribed in certain sports, which raises the importance of further evidencing the practices of SCCs in other sports too.

Flexibility exercises were commonly prescribed by 99% of SCCs, whereas, dynamic (98%), active (94%) and static (85%) stretching was reported as being used “sometimes” to “commonly” (Table 2). Dynamic stretching was more commonly employed compared to previous studies in NFL (11) (54%), NHL (12) (64%), MLB (13) (81%), rugby union (21)

(86%) and NBA (37) (90%), whereas, static stretching was the same as reported in NFL (11) (85%), above rugby union (21) (70%), and below NBA (37) (100%) and MLB (13) (100%). Furthermore, similar to prior research ballistic stretching was deemed least popular, however, results in this study (57%) indicated ballistic stretching to be more commonly employed compared to the NHL (12) (18%), MLB (13) (19%), NBA (37) (25%), and NFL (11) (36%). Although, it was the least recommended it is still surprising that a large proportion of SCCs are using ballistic stretching given recommendations not to use this due to an increased risk of injury (28). Whereas, in regards to the time which athletes were encouraged to complete flexibility exercises, before and after workouts and practice, and independently/athlete led were most commonly reported, similar to other studies (11-13,21,37). Warming up prior to activity has been advised in a systematic review and meta-analysis of 32 studies, that shown an appropriate warm up improved physical performance in 79% of studies assessed (16). Whereas, performing further static or dynamic stretches in addition to a comprehensive warm-up shown no effect on flexibility, high-intensity running, jumping, or change of direction performance, irrespective of athletes perceiving this to have additional performance benefits (3). However, giving athletes the responsibility to independently conduct stretches as reported in this study may allow them to feel more confident and psychologically prepared for the subsequent activity, therefore, should not be discouraged (3).

The present study adapted a survey previously used in studies investigating the practices of SCCs, which allows for comparison of practice with these coaches. Respondents of this survey were from 48 sports, 17 countries and different expertise levels, therefore providing an inclusive overview of practices. SCCs had academic and professional qualifications commensurate or exceeding that of previous surveys. Many areas surveyed demonstrated similar responses to those received by SCCs in other studies (e.g., use of physical testing and Olympic Weightlifting), whereas it was observed majority of practices by SCCs in

this study adhered to contemporary research and practical guidelines in strength and conditioning. This study also provides original insight into the practices of SCCs in regards to the types of resistance training exercises used, integration of technology, monitoring of athlete wellbeing, internships and opinions on future trends in strength and conditioning.

PRACTICAL APPLICATIONS

Based on the findings of this study, the following practical applications can be considered by SCCs: Internships play an important role in providing SCCs a chance to apply theory to practice and obtain foundational knowledge prior to completing a strength and conditioning certification and/or obtaining employment. Working in more than one sport, allows for diverse experience and provides opportunities for SCCs to develop their knowledge and practice. SCCs should "focus on the basics" in terms of program development (strength, power, speed, agility and flexibility) and monitoring player progress through physical testing. Periodization is important and including less strength and conditioning sessions in-season assists with recovery, while reducing strength and conditioning sessions prior to competition is important for optimal performance. Monitoring athlete well-being is becoming increasingly important and should be a consideration for SCCs. Lastly, due to the current use and desired integration of technology, it is important SCCs keep up to date with such advances and ensure their use is appropriate for their purpose.

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Insert Appendix 1 here

Figure 1

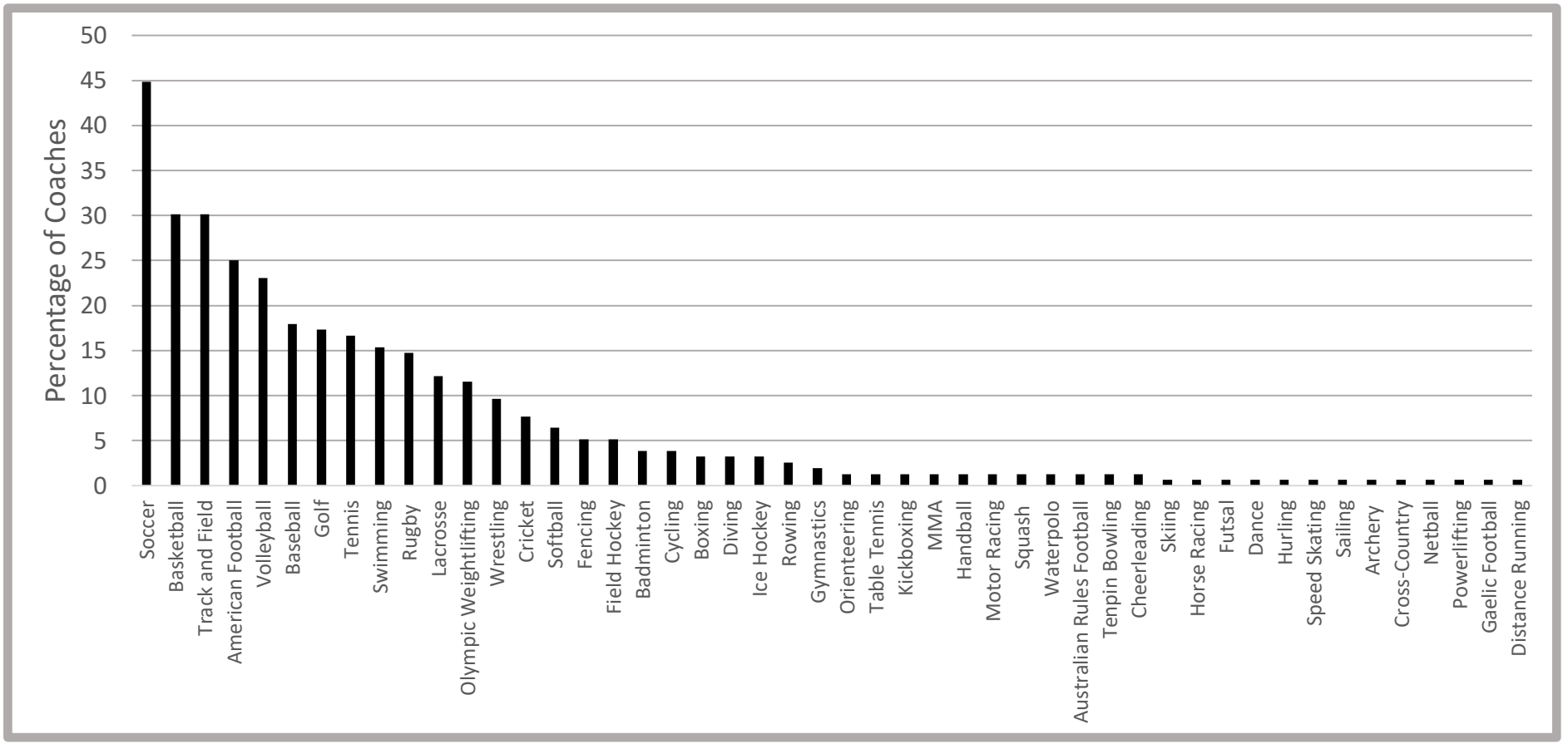

Figure 1. Sports strength and conditioning coaches surveyed reported currently working with.
*Some strength and conditioning coaches responded to working in more than one sport.

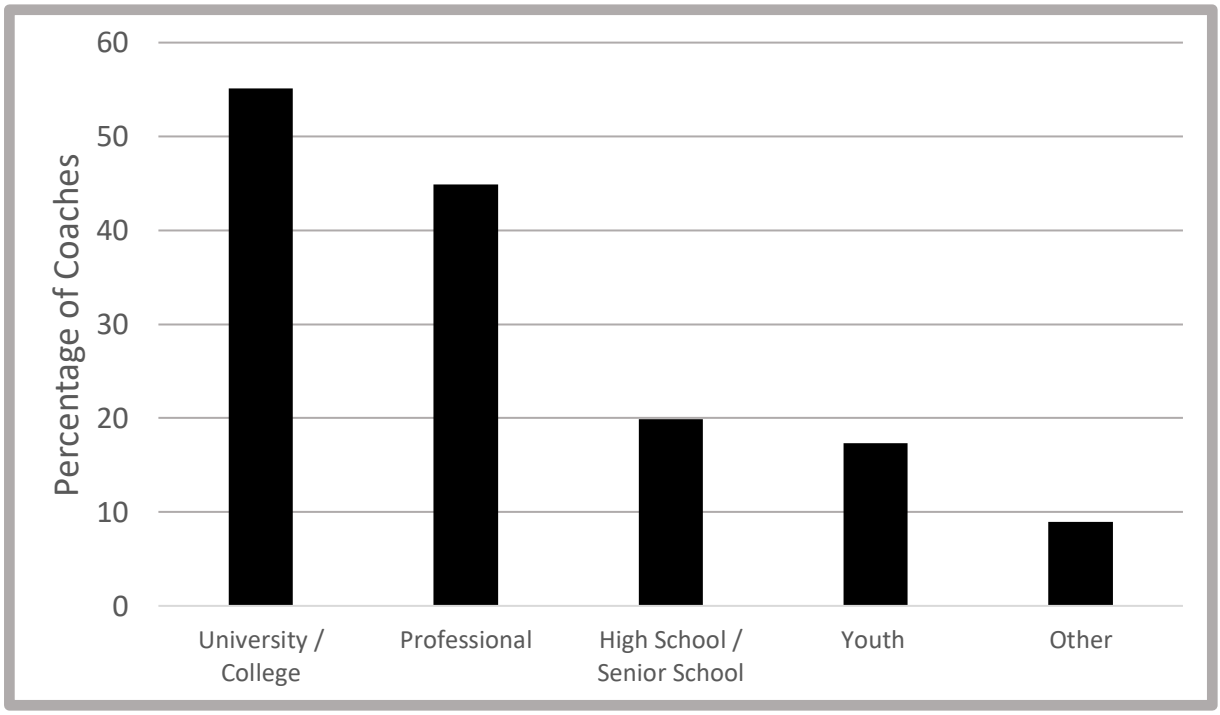

Figure 2. Level of athlete strength and conditioning coaches surveyed reported currently working with.

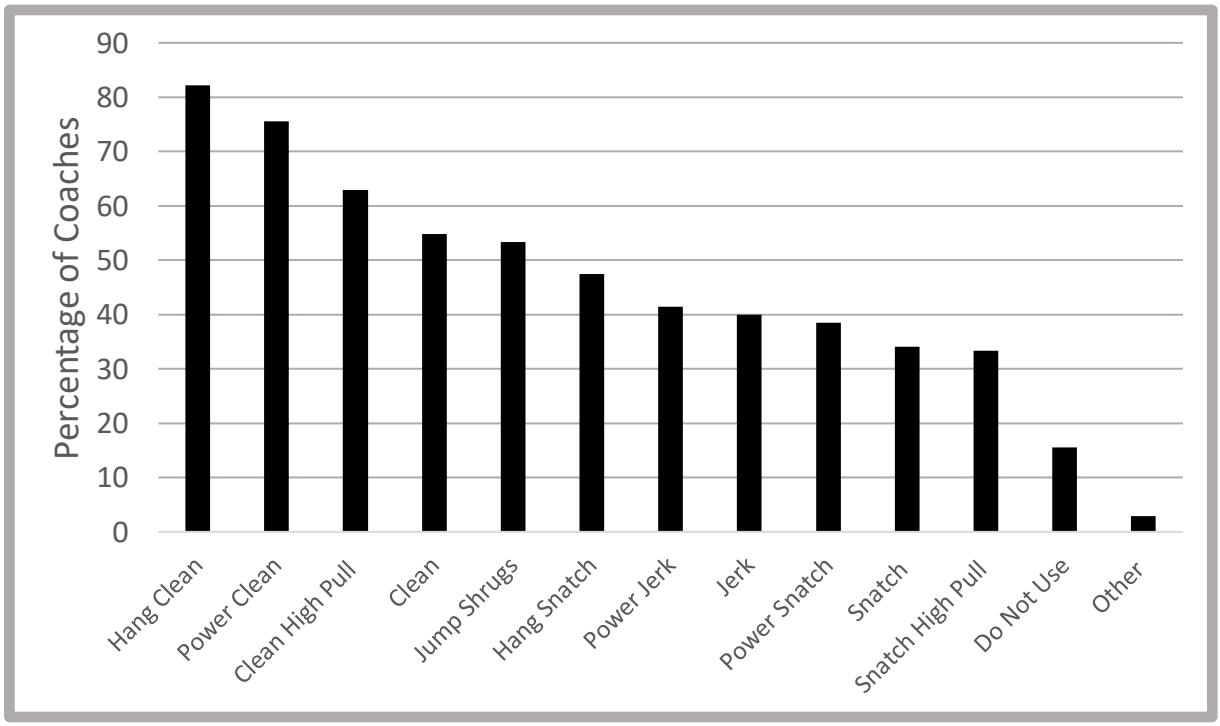

Figure 3. Percentage of different Olympic Weightlifting exercises strength and conditioning coaches surveyed prescribe.

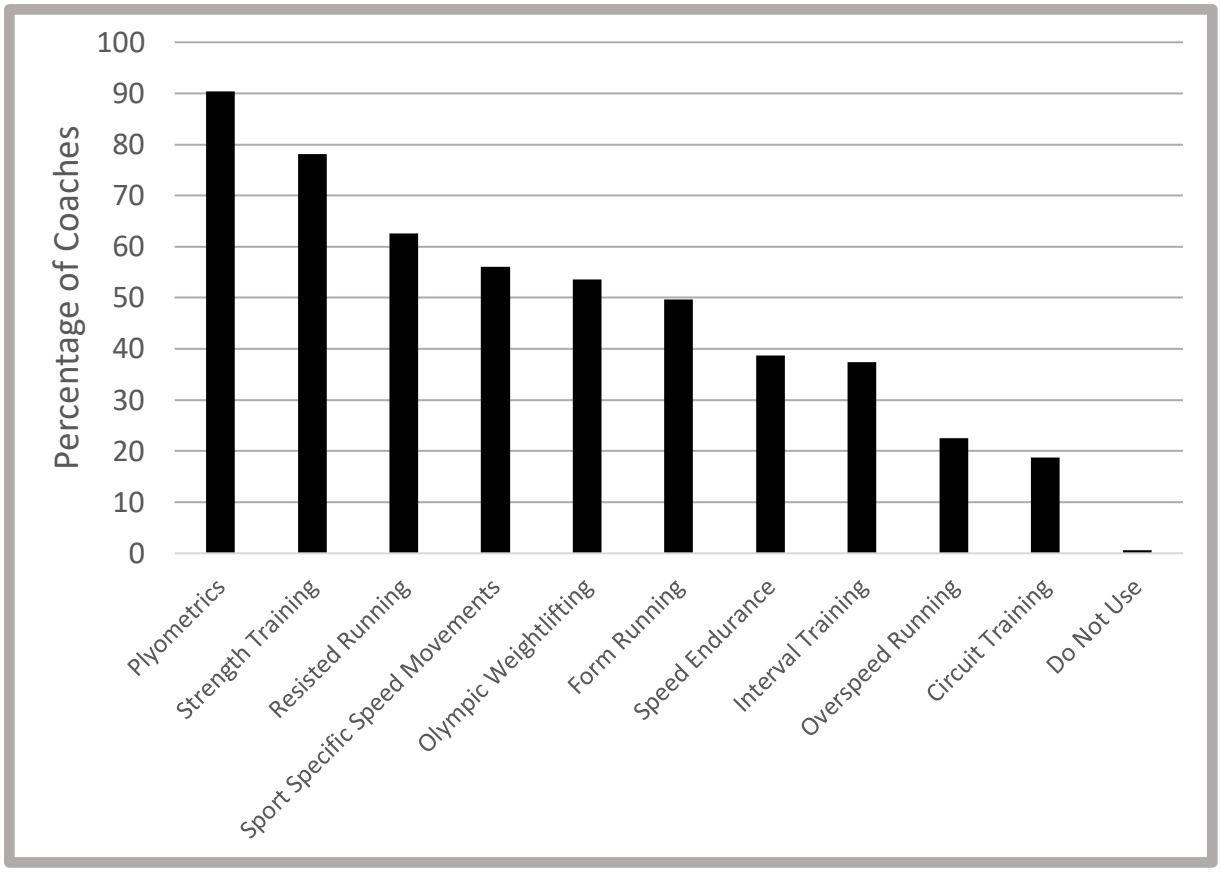

Figure 4. Percentage of different exercises strength and conditioning coaches surveyed prescribe for speed development.

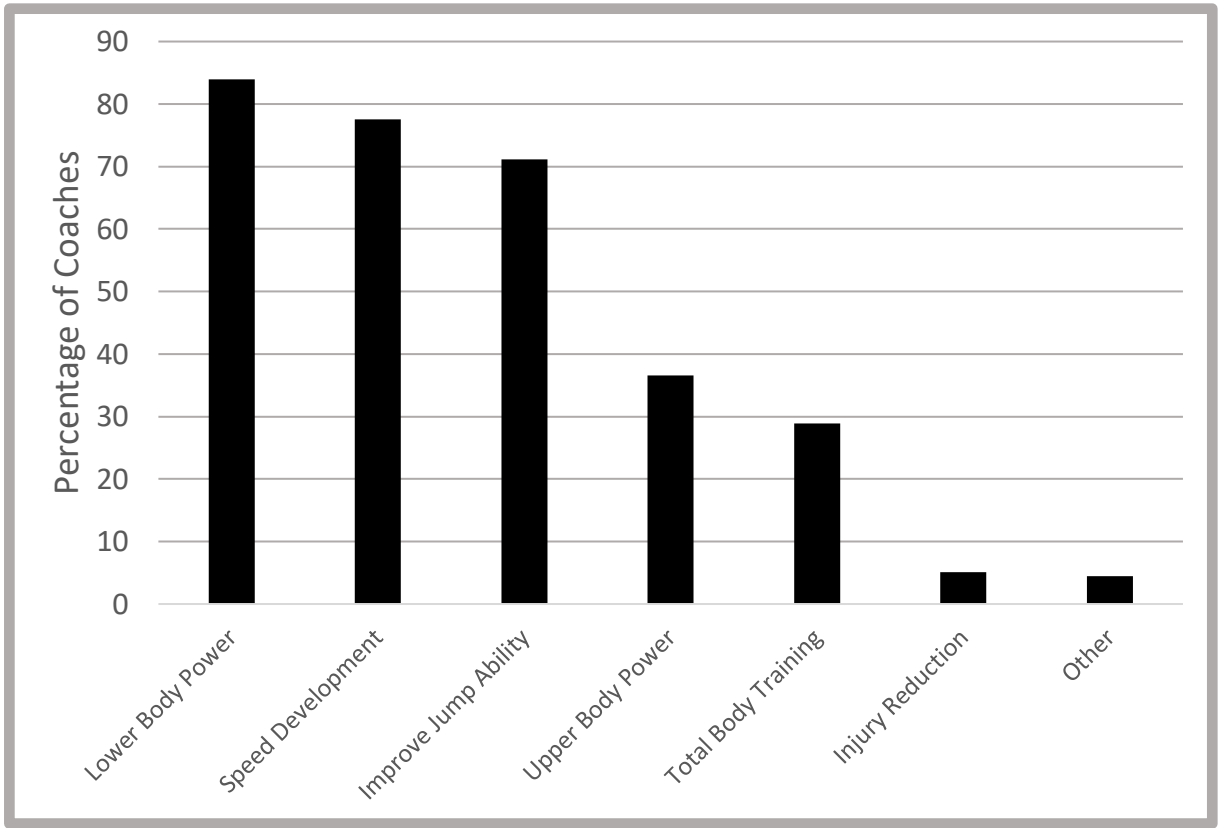

Figure 5. Different purposes for prescribing plyometric exercises and the percentage of strength and conditioning coaches surveyed who reported each purpose as their basis for using plyometrics.

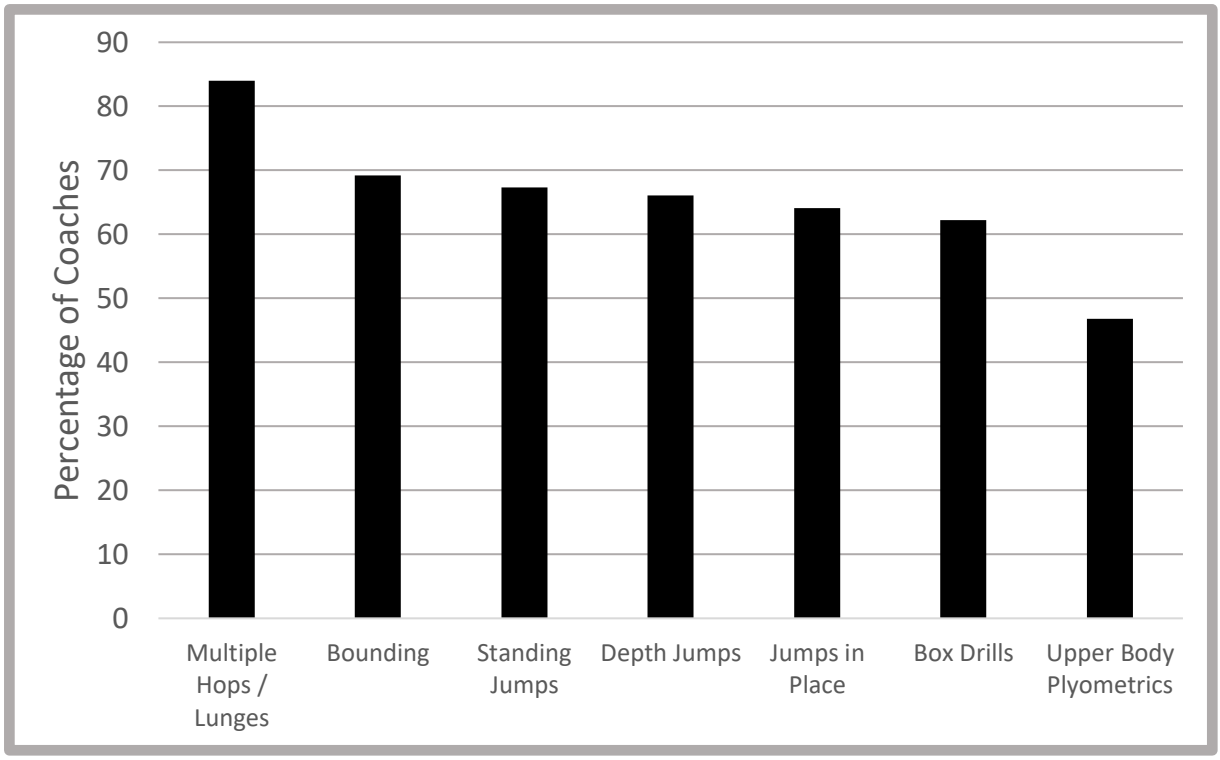

Figure 6. Percentage of different exercises strength and conditioning coaches surveyed prescribe for plyometrics.

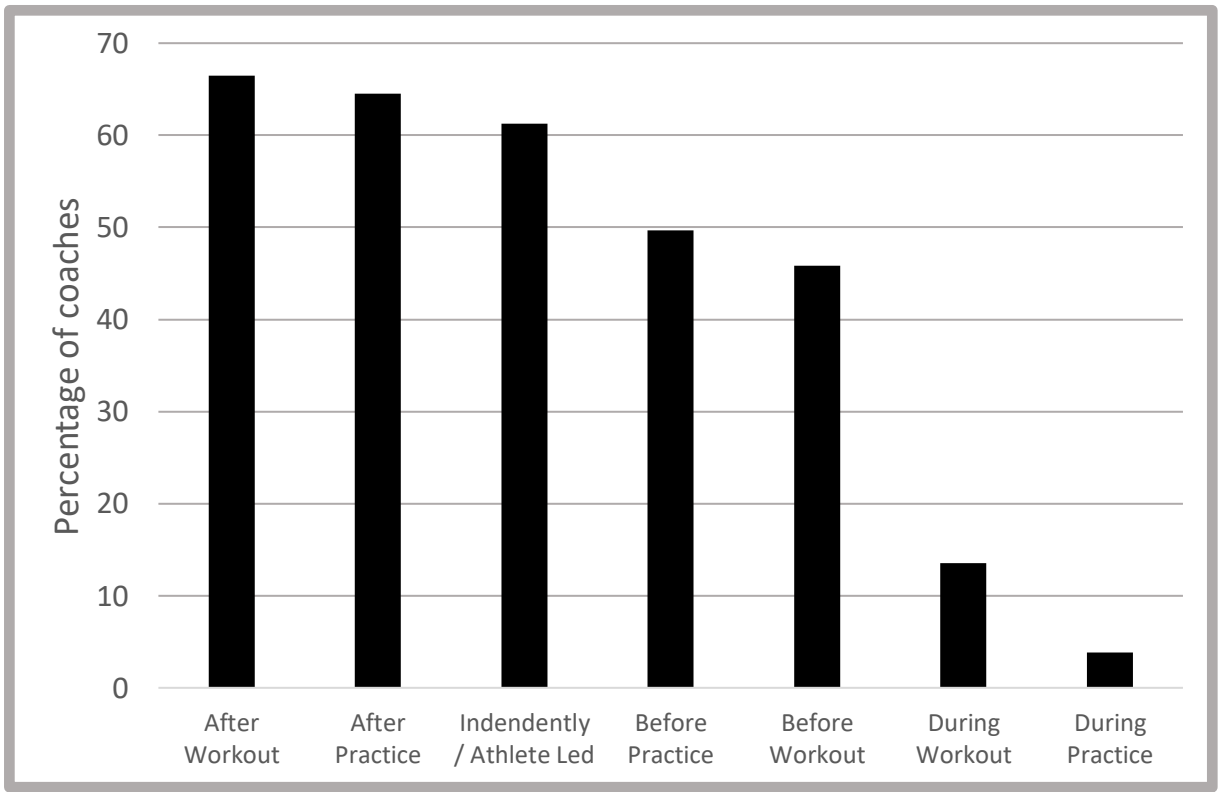

Figure 7. Different times for prescribing flexibility exercises and the percentage of strength and conditioning coaches surveyed who reported prescribing flexibility exercises at these times.

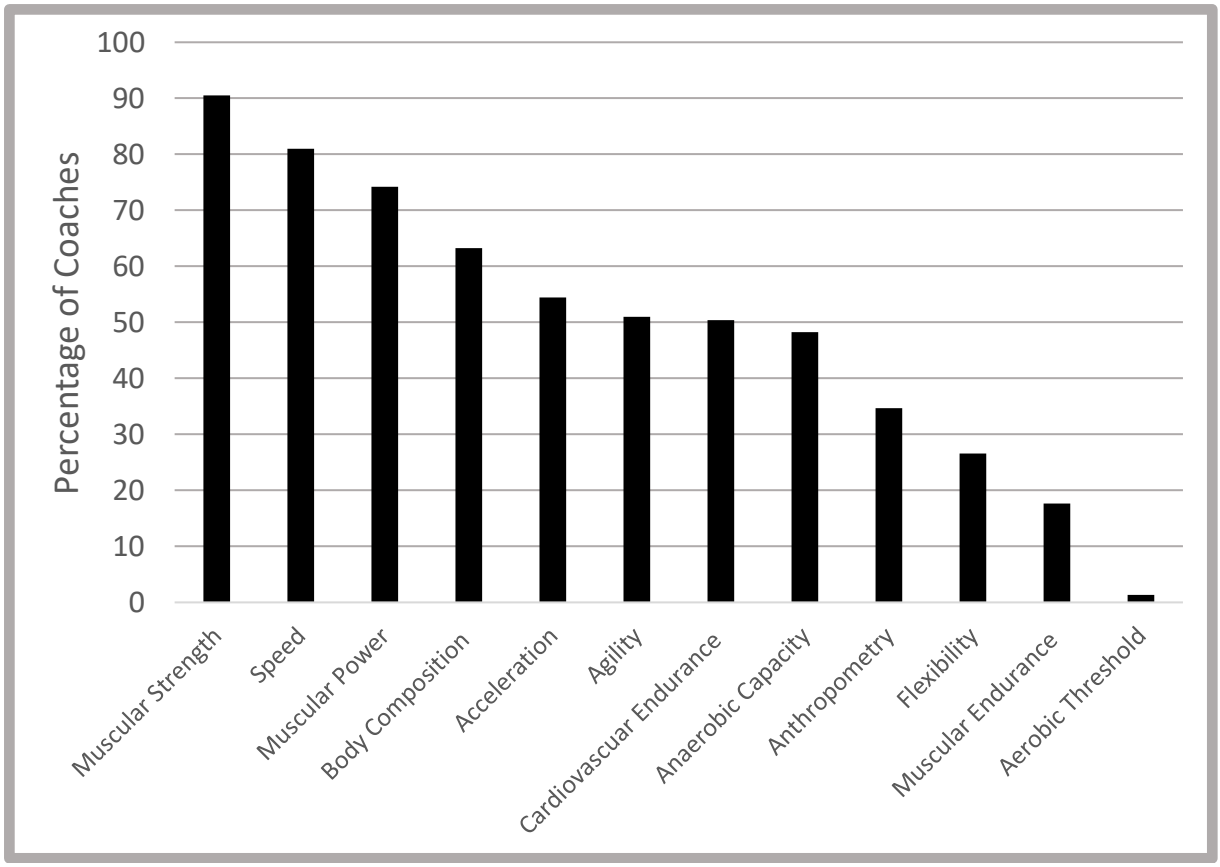

Figure 8. Different physical tests used by strength and conditioning coaches and the percentage of strength and conditioning coaches surveyed who reported using each physical test with their athletes.