Practices of strength and conditioning coaches across Chinese high–performance sports

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Abstract

This study used an online survey to investigate the practices and perspectives of strength and conditioning coaches (SCCs) across different high–performance sports in China. The survey comprised of the following sections: (a) background information, (b) muscular strength and power, (c) speed, (d) endurance, (e) plyometrics, (f) flexibility, (g) physical testing, (h) technology use, and (i) programing. In total, 93 SCCs from 44 high–performance sports across 25 provinces/municipalities participated in this study (age 31.5 ± 6.9 yrs, experience as a SCC 5.5 ± 4.4 yrs). Periodization strategies were used by 97% of SCCs. Clean and derivatives (37%) were deemed the most important exercises for strength and power development. Heart rate (85%) and repetition maximum (72%) were the most used methods for determining set loads in endurance and strength training, respectively. Box drills (91%) were the most prescribed plyometric exercise, and dynamic stretching (91%) was the most prescribed flexibility exercise. All SCCs physically tested their athletes and 95% frequently used technology–based equipment. For open–ended questions, 30% of SCCs would change their programs by improving monitoring, testing, equipment, and facilities. Thirty-nine percent of SCCs believed digitization and monitoring will be prominent future trends. The results indicated that most practices of SCCs in Chinese high performance–sports were dissimilar to those of SCCs in other countries. SCCs generally prescribe training

according to the needs of sports. However, the interferences of many external factors also affected the scientific nature of training prescription.

Keywords: program design, survey, knowledge translation, future trend, physical test, perspective

Introduction

Strength and conditioning training supports athletes sports performance and has developed rapidly in recent decades. The strength and conditioning coach (SCC) is responsible for planning, undertaking, and reviewing the execution of strength and conditioning training programs. Accordingly, they require a strong understanding of scientific knowledge regarding physiology, psychology and biomechanics, and excellent inter–personnel skills to maximize coaching effectiveness.[1] However, applying scientific recommendations may lack ecologicial validity.[2-4] Therefore, it is important to understand the contemporary practices and perspectives of SCCs, to help develop a thorough understanding of where science meets practice and where additional bridges need to be built.

To date, the practices of SCCs have been broadly investigated, with studies combining evidence across different sports, levels, and countries.[5-11] Whereas, other studies have focused on specific sports, such as football,[12] basketball,[13] baseball,[14] hockey,[15] wrestling,[16] rugby,[8, 17, 18] swimming,[19] cricket,[7, 9, 20], and soccer[10, 21], level of

athlete, such as high school,[5, 8] professional sports teams,[9, 10, 12-15, 18, 20] elite sports teams[16, 17, 19, 21], and countries, such as the United States of America,[12-15, 22, 23] Iran,[16] South Africa,[7, 8] Brazil,[21] and Argentina.[18] However, only a few studies have investigated the practices and perspectives of strength and conditioning in East Asian countries, but exclusively focused on sports coaches and athletes, with SCCs yet to be investigated.[24, 25] Previous research demonstrated that differences and commonalities exist in the practices of SCCs working in different sports and levels. For example, cardiovascular endurance tests are used less in baseball (24%) than ice hockey (78%).[14, 15] Similarly, SCCs in rugby commonly assessed body composition (93%) at the elite level[17] but not in high school (0%).[8] Furthermore, research suggests countries can also influence the implementation of strength and conditioning, such as the culture/history,[26] funding,[18, 21] scientific level, and coach education.[7]

Although prior research provides valuable data for understanding the practices of SCCs, there is limited evidence looking at certain countries that widely participate in high-performance sports (e.g., China). This is surprising given the role strength and conditioning plays in the multidisciplinary support athletes receive and its influence in driving the development of Chinese sport. A survey investigating the practices of SCCs in China would provide valuable insight into this understudied population. Therefore, this study aimed to survey high–performance SCCs in China to comprehensively describe the common and unique practices employed and perspectives held across a wide range of sports.

Method

Experimental Approach to the Problem

A cross–sectional explorative study was designed to survey SCCs across high–performance sports in China to ascertain their current strength and conditioning practices. To target the relevant population, this study adopted convenience sampling.

Subjects

The inclusion criteria for SCCs in this study was working with athletes competing at national or international level in any sports for at least three months within the previous 12 months. Accordingly, SCCs were targeted from high–performance sports teams, universities, sports science institutes, private companies, sports administration centers, and national/provincial training bases. The study was approved by the ethics committee of the Shanghai University of Sport (Approval code: 1027720211RT131).

Data collection procedures

The survey was adapted from previous research[11] and developed using open access survey administration application WJX (问卷星，www.wjx.cn). Pilot testing was conducted by the 10 members of the extended research group, then by three accredited SCCs, whom all held doctoral degrees (Ph.D's), for three rounds 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 distributed through the corresponding author's social networks (e.g., previous colleagues) and by contacting directors of sports teams in different provinces and municipalities.

Survey

The survey was presented in Chinese and had 63 questions (49 fixed response and 14 open–ended). Of the 14 open–ended questions, 9 were feedback on each section. The survey consisted of the following sections: (a) basic information, (b) muscular strength and power, (c) speed, (d) endurance, (e) plyometrics, (f) flexibility, (g) physical testing, (h) technology use, and (i) programing. Some questions allowed respondents to select multiple responses (e.g., when do you prescribe plyometrics); therefore, some had more responses than others. The start of the survey included an explanation of the purpose and the confidentiality of information.

Statistical Analyses

All responses from WJX were downloaded into a Microsoft Excel spreadsheet (Microsoft Corporation, Redmond, WA). Fixed response questions were assessed using frequency analysis. Whereas a six–stage thematic analysis[27] approach was used to assess open–ended questions that included (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 approach provided clear and

distinct themes emerging from the raw data for each open–ended question. In some cases, responses provided sufficient information to create multiple themes. If the SCC did not prescribe a particular aspect of training, they were directed to the next section of the survey. Furthermore, some questions may show a varying number of responses which is due to SCCs providing invalid or no answers for a particular question, which were subsequently removed. Under the above circumstances there will be a lower response rate shown to certain questions. Results are presented in percentages (rounded to the nearest whole number) using the formula number of responses selected/the number of valid answers.

Results

Demographic Information

The digital survey was completed by 123 SCCs which took ~25 min. The lead author pre–checked the responses, and 30 surveys (24%) were considered invalid due to the SCCs not meeting the inclusion criteria of working with high–performance athletes. Consequently, 93 SCCs were included in this study (n = 82 male, n = 11 female; age 31.5 ± 6.9 yrs, range: 21–55 yrs; experience as an SCC 5.5 ± 4.4 yrs, range 0.5–23 yrs). Responses were received from 25 provinces/municipalities, with the most reported being Beijing (33%), Guizhou (11%), and Hebei (10%). In total, SCCs worked across 44 sports. (Figure 1).

Insert Figure 1 About Here

Muscular Strength and Power Development

Periodization, Set Loads, and Recovery. All SCCs planned and undertook strength and power training, with 97% using periodization strategies to structure their strength and power programs. The methods for determining set loads were ranked as follows: repetition maximum (RM) (72%), velocity (46%), predicted repetition maximum (42%), rating of perceived exertion (RPE) (38%), athlete-determined (27%), heart rate (HR) (23%), subjective/guess (13%), train to failure (8%), trial and error (2%), other (relative intensity) (1%), and not determined (1%). The recovery time prescribed by SCCs between strength and conditioning training, sports practice, and competition are presented in Table 1.

Preparation Period. The number of strength training sessions prescribed in this period was 2 (41%), 3 (39%), 4 (11%), 1 (8%), 5 (1%), and 6 sessions (1%). The duration of sessions was 46–60 min (29%), 61–75 min (15%), 76–90 min (13%), 16–30 min (12%), 90+ min (12%), 31–45 min (11%), 0–15 min (8%), and other (40–120 min, depends on what kind of purpose) (1%). The set ranges used were 3–4 (65%), 5–6 (30%), 1–2 (2%), 7–8 (1%), and other (2–4, 4–6) (2%). The repetition ranges used were 4–6 (44%), 7–9 (23%), 10–12 (19%), 1–3 (8%), 13–15 (3%), other (depending) (2%), and 15+ (1%).

Competition Period. The number of strength training sessions prescribed was 2 (49%), 1 (31%), 3 (14%), 5 sessions (2%), other (depends on the coach) (2%), and 4 sessions (1%). The duration of sessions was 31–45 min (29%), 16–30 min (27%), 46–60 min (26%), 0–15 min (8%), 76–90 min (5%), 61–75 min (4%), and other (depends on the coach) (1%). The set ranges used were 3–4 (59%), 1–2 (34%), 5–6 (4%), 7–8 (1%), and other (depends on the head coach) (1%). The repetition ranges used were 4–6 (44%), 1–3 (35%), 7–9 (10%), 10–12 (8%), other (1–6, depends on the head coach) (2%), and 15+ (1%).

Resistance Training. The muscle contraction modes of resistance training predominantly used were concentric (88%), eccentric (77%), isometric (41%), and other (plyometrics, isokinetic) (5%). Weightlifting and associated derivatives were prescribed by 95% of respondents (see list of exercises in Figure 2). The top five exercises prescribed by SCCs in their training programs were ranked in order and presented in Table 2.

*** Insert Figure 2 About Here***

Insert Table 2 About Here

Endurance Development

Methods, Exercises, Set Loads. Endurance training was prescribed by 94% of SCCs, with the most common methods used for endurance development being high–intensity interval training (73%), circuit training (71%), moderate–intensity continuous training (53%), low–intensity continuous training (48%), incremental intensity training (38%), and decreasing intensity training (17%). The exercises used by SCCs for endurance development are shown in Figure 3. The most reported methods for determining set loads were HR (85%), velocity (55%), RPE (55%), power (39%), blood lactate (36%), tempo (32%), talk test (16%), athlete determined (9%), not determined (1%), and other (kg) (1%).

Preparation Period. The number of endurance training sessions prescribed was 2 (51%), 3 (21%), 1 (20%), 4 (4%), and 6 sessions (1%). The duration of the sessions was 16–30 min (26%), 46–60 min (23%), 31–45 min (22%), 61–75 min (10%), 0–15 min (7%), 76–90 min (6%), 90+ min (3%), and other (depends on the sports/stage/athlete level/purpose) (2%).

Competition Period. The number of endurance training sessions prescribed was 1 (48%), 2 (24%), 0 (22%), 3 (3%), 4 (1%), and 6 sessions (1%). The duration of the sessions was 0–15 min (36%), 16–30 min (30%), 46–60 min (15%), 31–45 min (13%), 61–75 min (3%), 76–90 min (1%), 90+ min (1%), and other (depends on the needs)

(1%).

Insert Figure 3 About Here

Plyometrics

Plyometric exercises were prescribed by 91% of SCCs, for the improvement of lower body power (78%), speed development (61%), improve jumping ability (54%), total body training (51%), upper body power (47%), and injury reduction (42%). The time of year for prescribing plyometric exercises was predominantly during the preparatory period (51%), whole year round (34%), competitive period (31%), and transitional period (24%). Regarding SCC integration of plyometrics into their training schedule, complex training (67%) was reported most, followed by before weights (48%), on separate days (31%), and after weights (19%). The prescribed plyometric exercises are shown in Figure 4.

Insert Figure 4 About Here

Speed Development

Speed development exercises were prescribed by 90% of SCCs in their programs, with an overview of these exercises presented in Figure 5.

Insert Figure 5 About Here

Flexibility Development

Flexibility exercises were prescribed by 94% of respondents, with the most common times for implementing flexibility training being after a workout (75%), before a workout (68%), before practice (62%), after practice (60%), additional sessions (46%), during a workout (17%), and during practice (7%). The duration of flexibility sessions was 11–15 min (33%), 6–10 min (26%), 16–20 min (25%), 21+ min (13%), 0–5 min (1%), and other (10–30min, depends) (1%). An overview of the frequency that SCCs prescribe different methods of flexibility exercises are presented in Table 3.

Insert Table 3 About Here

Physical Testing and Technology Use

All SCCs conducted physical testing with their athletes, and 86% developed an annual physical test schedule. The most common times of year for physically testing athletes were all year round (63%), preparatory period (32%), transitional period (16%), competitive period (6%), and other (near the competition period) (1%). The physical tests implemented by SCCs are shown in Figure 6. The factors affecting physical testing

arrangements were the needs of sports coaches (88%), facilities and equipment (71%), cooperation of athletes (65%), the use of equipment (51%), data analysis (40%), selection of the testing methods (34%), and report writing (20%). Technology–based equipment was used by 95% of respondents, with an overview of equipment used presented in Figure 7.

Athlete well-being was monitored by 98% of SCCs, with the most common methods used being daily chat and observation (71%), mobile applications (60%), verbal interviews or questionnaires (43%), written questionnaires (29%), and other (communicating with sports team doctors) (1%).

Insert Figure 6 About Here

Insert Figure 7 About Here

Programing

Four open–ended questions were asked in the final section of the survey 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 4–7.

Insert Table 4~7 About Here

Discussion

The main finding of present study was that most practices prescribed by Chinese SCCs were not similar to SCCs surveyed in other countries, except a small part of the practice. This is the first study to investigate the practices of SCCs across different high–performance sports in China. The data provided allows a detailed understanding of the habitual and contemporary training practice strategies, routines, and perspectives of these professionals. The findings can be used by coaches and researchers as a basis for training and research regionally in China and the international community across different sports and levels.

Strength and power training

All SCCs prescribed strength and power training. During the preparation period, most SCCs prescribed 2–3 strength and power training sessions per week, for 46–60 minutes, including 3–6 sets and 4–12 repetitions per exercise. In the competition period, most SCCs prescribed 1–2 strength and power training sessions per week, for 16–60 min including 1–4 sets and 1–6 repetitions per exercise. These results are similar to previous surveys across different sports at the high school level and in multi–level sports (e.g., university, professional, high school, youth, other),[5, 11] but the number and duration of sessions during the competition period were slightly less and shorter in duration. In this

survey, SCCs reported prescribing higher training volumes during the preparation compared with the competition period. Typically training volumes in the competition period were reduced by 1 session per week, 15 min per session, 2 sets and 3 repetitions per exercise. This arrangement corresponded with 97% of SCCs using periodization strategies in this survey, with the overarching aim of supporting athletes to reach peak physical and mental condition for their sports at specified time points.[28]

Ninety–five percent of respondents prescribed weightlifting exercises or derivatives in strength and power training, with the power clean being the most common exercise (84%). It was similar to previous surveys across different sports,[11] as weightlifting exercises and derivatives can support the improvement in specific physical tests and movements, such as the 1RM squat, sprint (10-m, 20-m, and 36.5-m), rate of force development, vertical jump, and 1RM power clean.[29-34] The clean and associated derivatives (37%) were the most frequently selected exercises, which was in contrast with recent surveys, which stated that the squat and its variations were the most important exercise across various professional sports.[9-16, 21] This may be because the prominence of weightlifting in China.

Endurance training

Ninety–four percent of SCCs prescribed endurance training. During the preparation period, most SCCs prescribed 1–3 endurance training sessions per week, for 16–60 min each session. During the competition period, most SCCs prescribed 0–2 endurance

training sessions per week, for 0–30 min each session. The results show that endurance training sessions prescribed by SCCs were noticeably less than strength and power training sessions during the two periods. Because not all sports require superior endurance (e.g., golf and shooting) and coaches at the professional level have frequently reported time constraints as a limiting factor to their program design.[10, 35] However, endurance training was consistent with strength training in the way SCCs manipulate the total training load (reducing the training volume after entering the competition period), which again demonstrates the use of periodization strategies.

The most common training method used by coaches was high–intensity interval training (73%), which can effectively improve the maximum oxygen uptake of athletes.[36-38] The exercise most prescribed by SCCs was running (80%), which is logical given this being fundamental to various sports and requiring limited equipment and facilities, which helps overcome a lack of facilities and equipment, which was the the third most reported issue hindering the application of strength and conditioning by SCCs (see Table 5). The most commonly used method for SCCs to determine training load for endurance development was HR (85%), which was linked with the common prescription of running.[39] As this is the first study to investigate the endurance training practices of SCCs, the information available does not allow for comparison with other studies. Further investigation of more detailed endurance training practices for different sports is needed.

Plyometrics

Ninety–one percent of SCCs reported programing plyometric exercises, with the most prescribed exercises being box drills (e.g., box jump up) (91%) and the most reported purpose being to develop lower body power (78%), higher than results from previous surveys.[5, 9-18, 21] This is a misunderstanding on behalf of many SCCs, because box drills usually reduce the ECC load by using low–medium height boxes, which may be desirable for some stages of training (e.g., during rehabilitation), but not for the long-term development of high–performance athletes due to its relative moderate training intensity produces less training stimulation compared to training using high height boxes. The prescription rate of upper body ballistic training was 65%, while only 47% of SCCs prescribe plyometrics to develop upper body power. This is similar to that reported in previous studies whereby upper body training in baseball (purposeful 48% *vs.* actual 76%)[14] and rugby (purposeful 0% *vs.* actual 63%),[17] indicating that even if SCCs have no clear purpose, they usually prescribe such exercises.

Speed training

Ninety percent of SCCs prescribed speed training using 14 different training methods, which is more than in previous studies.[5, 9-18, 20, 21] The most used method in this study was maximum speed sprinting (60%), and there was no training method with a relatively high usage rate. Previous studies have found some high–usage training

methods prescribed in specific sports, such as speed endurance in football (81%),[12] plyometrics in hockey (83%)[15] and wrestling (92%),[16] form running in baseball (100%),[14] maximum speed sprint and resistance running in cricket (100%)[20] and basketball (100%).[13] This supports the possibility that the concentration of training methods was weakened when more sports were added.[11]

Flexibility training

Flexibility exercises were prescribed by 94% of SCCs, with dynamic (91%), static (83%), and proprioceptive neuromuscular facilitation (PNF) (39%) stretching reported as being used "commonly". These findings were similar to previous multi–sport surveys,[5, 11] with dynamic (92% and 98%), static (63% and 85%), PNF (26% and 75%), showing that SCCs preferred dynamic stretching and were less willing to use pnf stretching. The less frequent use of PNF stretching may be related to the loss of performance it causes,[40, 41] complex mechanisms, and time constraints.[21] The prescription rate of dynamic stretching was similar to static stretching in this study, indicating that most coaches may combine these stretching methods forms in training, which is in line with research on stretching exercises.[42, 43] A typical arrangement was to perform dynamic stretching before training to enhance the preparation for warm–up and static stretching after training to relieve muscle tension and fatigue. However, this kind of training prescription was usually only for warm–up activities, which cannot meet the needs of all sports (such as gymnastics, rhythmic gymnastics, and artistic

swimming). Therefore, some coaches (46%) in such sports may also conduct additional flexibility training sessions because these sports require athletes to have extreme ranges of motion.

Physical testing

All SCCs reported physically testing athletes and mostly all year round (63%), similar to that reported in professional cricket (67%),[35] elite soccer (53%),[21] and multi–sports (54%),[11] but higher than all non–elite level SCCs surveys.[7, 10-13, 23, 35, 44-54] This may be due to elite/professional sports teams possessing more resources, financial support, and time with athletes.[18, 20] The competition period was the least time (6%) dedicated to testing, most likely because of fixed schedules and the head coach not wanting unnecessary sessions, which may interrupt an athlete's sports preparation.[45] The most tested variable was muscle strength (91%), similar to hockey (100%),[15] wrestling (97%),[16] rugby union (81 %, 97%),[17, 18] basketball (75%),[13] multi–sports (87 %, 90%),[5, 11] cricket (82 %, 100%),[9, 20] and soccer (81 %, 71%).[10, 21] This reflects the belief of SCCs that muscle strength is essential for athlete performance and is also consistent with the research evidence.[55] This survey further explored factors influencing the completion of physical testing by SCCs. The most common response was "the demands of the head coach" with open ended responses providing further information such as "we only can fill in the blanks provided by the head coach". This is possibly caused by China's unique sporting culture, which is directly related to the administrative

management system of Chinese high–performance sports teams. The leader responsibility system and the sports coach responsibility system are the management methods of China's high–performance sports teams, which directly leads to the fact that the sports coach dominates all training directions.

Technology use

Ninety–five percent of SCCs reported using technology–based equipment in their training programs, similar to that reported in cricket (100%)[9] and soccer (100 %, 88%),[10, 21] but higher than a survey across multiple levels (65%).[11] A discrepancy in testing rate may be because the multi–levels study respondents were not all elite–level SCCs which influenced the affordability and accessibility of equipment. Technology–based equipment plays a vital role for high–performance or elite–level sports teams to further enhance the performance of athletes. Therefore, the demand for technology–based equipment was greater in high–performance or elite–level sports teams. The most used equipment was to assess body composition (e.g., bioelectrical impedance analysis machine) (67%), which was consistent with the body composition test rate (69%). The use of the electronic jump mats (56%) was considerably lower than the test rate of muscular power (91%), which is surprising given the commonality of using jumps mats to assess prominent physical components of sports performance such as lower body power.[56] The test rate of aerobic capacity (65%) and anaerobic capacity (53%) were much higher than the utilization rate of the gas metabolism analyzer (13%) in this

survey. This may be due to this equipment being complicated to operate, time-consuming to analyze data, and expensive. Consequently, the respondents who commonly used this equipment in this study were SCCs with Ph.D. degrees. The above differences indicate that SCCs in this study commonly use field-friendly as opposed to laboratory-based equipment.

Limitations

Although the SCCs in this study were from 25 provinces/municipalities/autonomous regions and 44 sports in China, the sample size was not balanced across sports (mostly in track and field [12.9%]) and regions (mostly from Beijing [33%]), therefore, the results may be more attributed to these sports/regions. However, it may be due to track and field having the most sub–disciplines and most national teams are located in Beijing. In addition, the respondents spent ~25 min completing the survey, which was time–consuming and may have limited their intention to complete the survey and responses. However, it was deemed important to have a comprehensive survey of questions to build a strong evidence base being the first study on this topic area.

Conclusion

The present study and survey instrument was adapted from previous research investigating the strength and conditioning practices across multi–sports, levels, and countries,[11] which allowed direct comparisons to be drawn. The results demonstrated

that most practices prescribed by Chinese SCCs were not similar to SCCs surveyed in other countries, except for strength and power training volume, weightlifting exercises, flexibility training, and physical testing. This reflected the differences in collective knowledge shared by SCCs between China and other countries, which may be related to culture, education, equipment condition, and professionalization of strength and conditioning. The practices prescribed by SCCs were not highly consistent (e.g., test rate of muscular power *vs* the use of the electronic jump mats) in each section (such as), which indicates that they carried out targeted training according to the needs of the sports coached. In China, many external factors (e.g., colleague relationship) interfered with the training plan and implementation of SCCs, weakening the application of strength and conditioning training received by athletes.

Acknowledgments

The authors would like to acknowledge the time and contribution of SCCs in completing the online survey.

Conflict of interest

The authors declare no conflict of interest.

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Figure Captions

Figure 1. Sports strength and conditioning coaches (*n*=86) work in.

Note: Some SCCs responded to working in more than one sport.

Figure 2. Variety of different weightlifting exercises and derivatives that strength and conditioning coaches (*n*=93) prescribe.

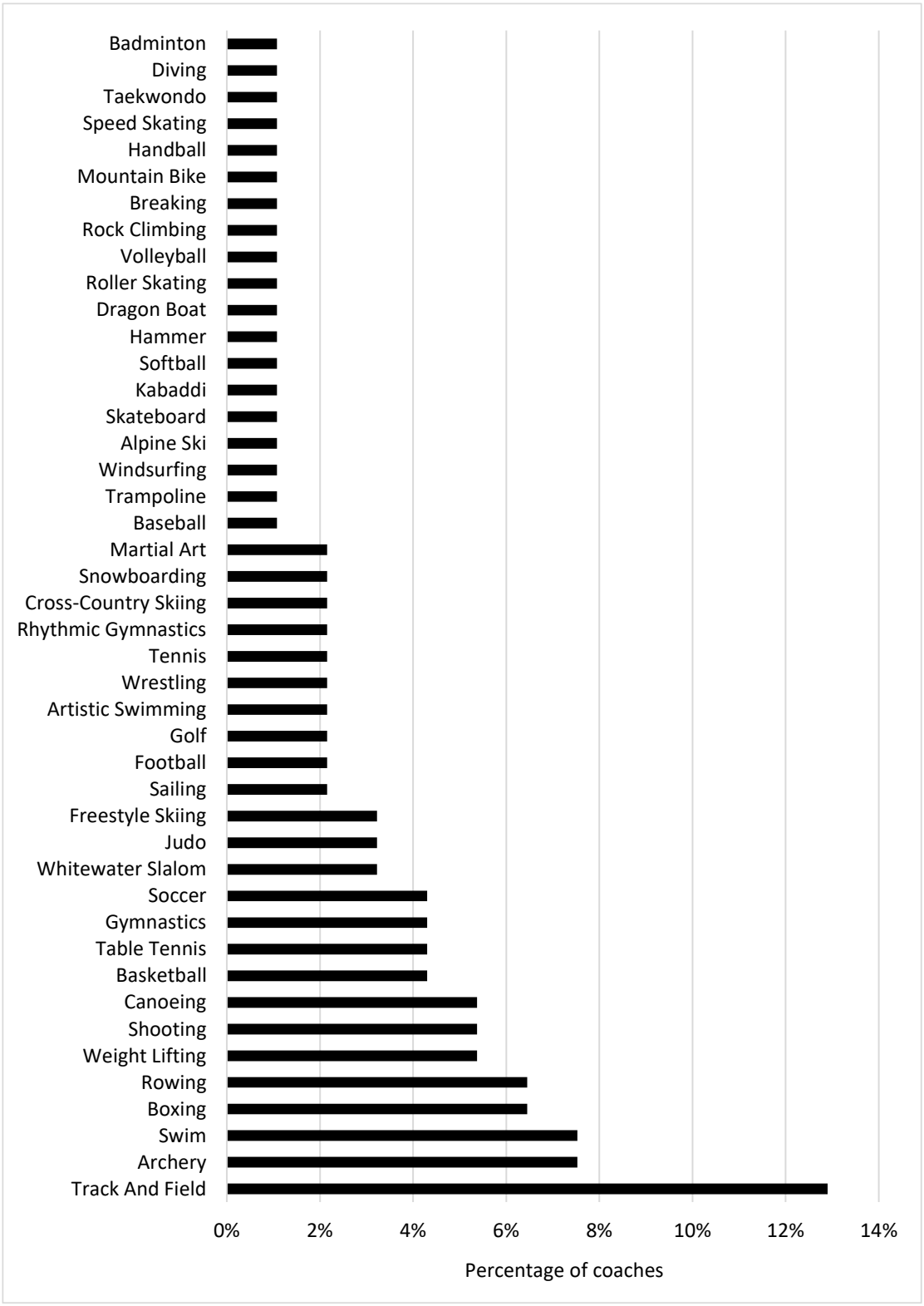
Figure 3. Variety of different endurance development exercises strength and conditioning coaches (*n*=87) prescribe.

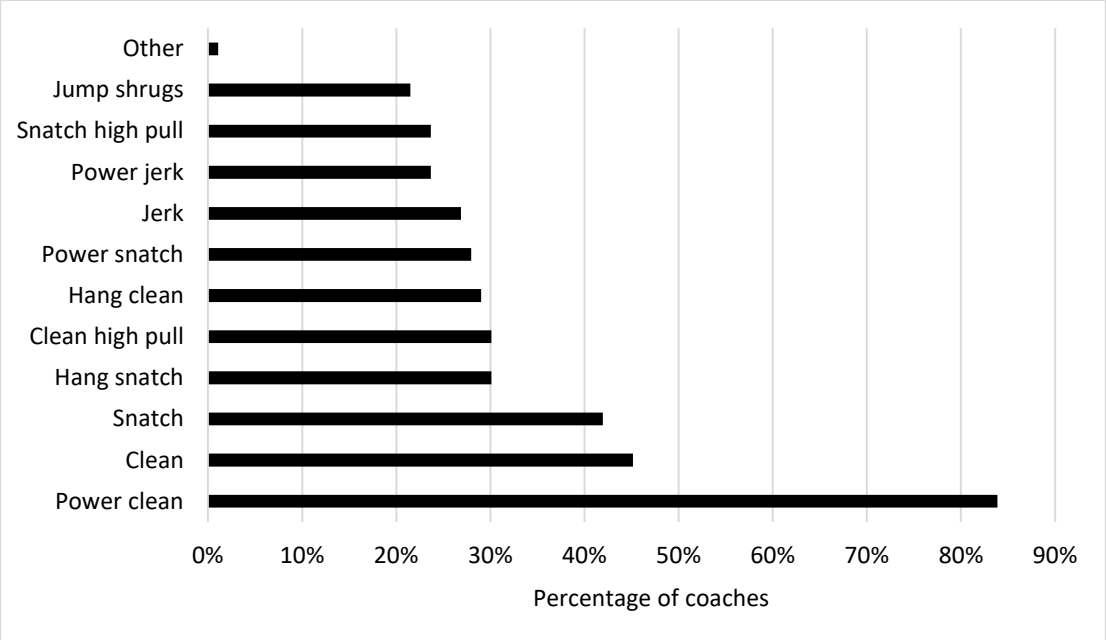
Figure 4. Variety of different plyometric exercises that strength and conditioning coaches (*n*=85) prescribed.

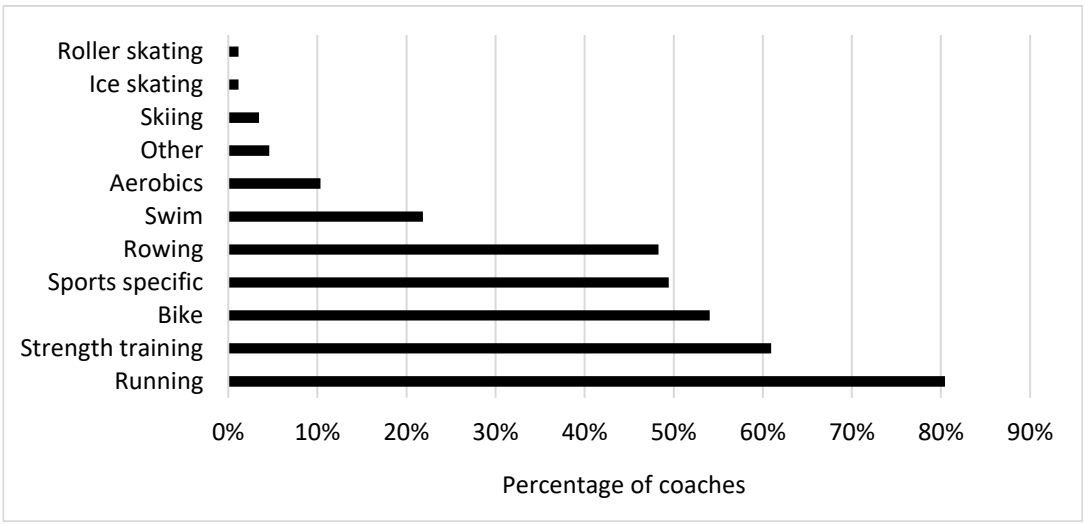
Figure 5. Variety of different speed development exercises that strength and conditioning coaches (*n*=84) prescribed.

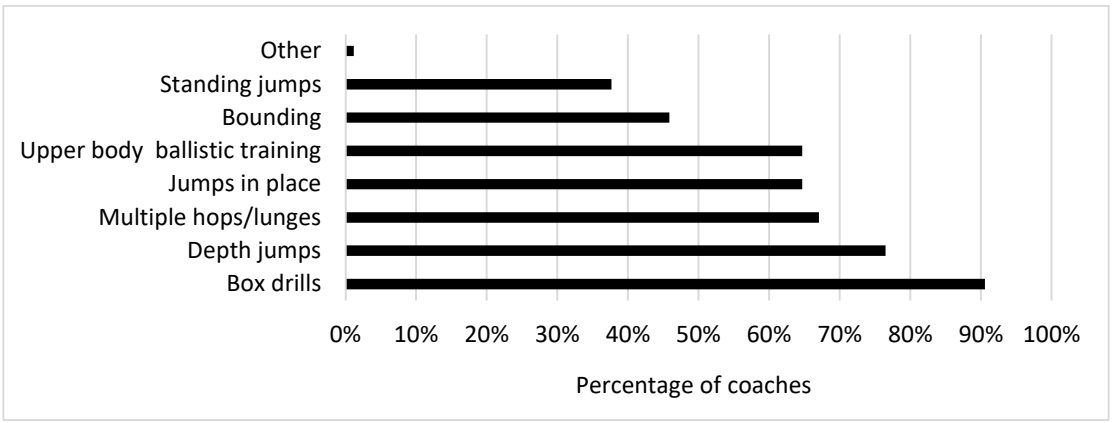
Figure 6. Different physical tests used by strength and conditioning coaches (*n*=93).

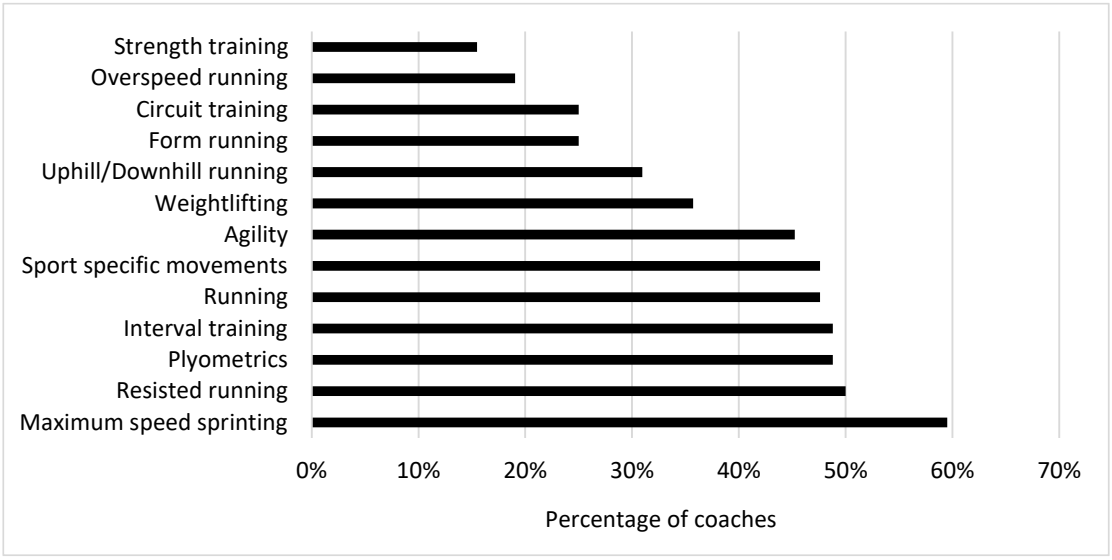
Figure 7. Technology–based equipment used by strength and conditioning coaches (*n*=93)

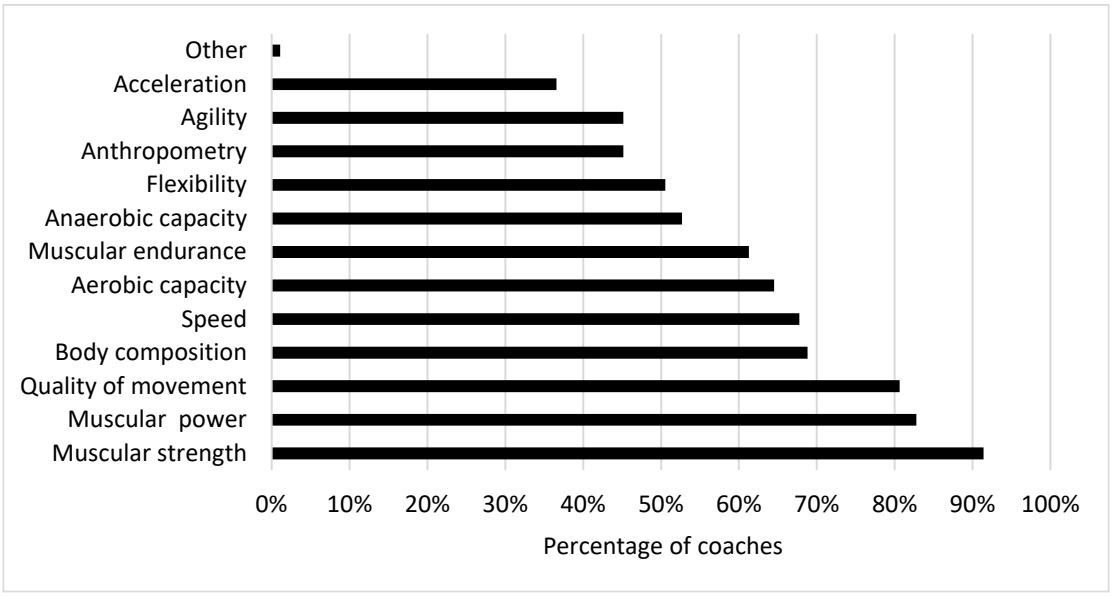

Badminton
Diving
Taekwondo
Speed Skating
Handball
Mountain Bike
Breaking
Rock Climbing
Volleyball
Roller Skating
Dragon Boat
Hammer
Softball
Kabaddi
Skateboard
Alpine Ski
Windsurfing
Trampoline
Baseball
Martial Art
Snowboarding
Cross-Country Skiing
Rhythmic Gymnastics
Tennis
Wrestling
Artistic Swimming
Golf
Football
Sailing
Freestyle Skiing
Judo
Whitewater Slalom
Soccer
Gymnastics
Table Tennis
Basketball
Canoeing
Shooting
Weight Lifting
Rowing
Boxing
Swim
Archery
Track And Field
0%
2%
4%
6%
8%
10%
12%
14%
Percentage of coaches


Other
Jump shrugs
Snatch high pull
Power jerk
Jerk
Power snatch
Hang clean
Clean high pull
Hang snatch
Snatch
Clean
Power clean
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
Percentage of coaches


Roller skating
Ice skating
Skiing
Other
Aerobics
Swim
Rowing
Sports specific
Bike
Strength training
Running
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
Percentage of coaches


Other
Standing jumps
Bounding
Upper body ballistic training
Jumps in place
Multiple hops/lunges
Depth jumps
Box drills
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of coaches


Strength training
Overspeed running
Circuit training
Form running
Uphill/Downhill running
Weightlifting
Agility
Sport specific movements
Running
Interval training
Plyometrics
Resisted running
Maximum speed sprinting
0%
10%
20%
30%
40%
50%
60%
70%
Percentage of coaches


Other
Acceleration
Agility
Anthropometry
Flexibility
Anaerobic capacity
Muscular endurance
Aerobic capacity
Speed
Body composition
Quality of movement
Muscular power
Muscular strength
0%
10%
20%
30%
40%
50%
60%
70%
80%
90%
100%
Percentage of coaches

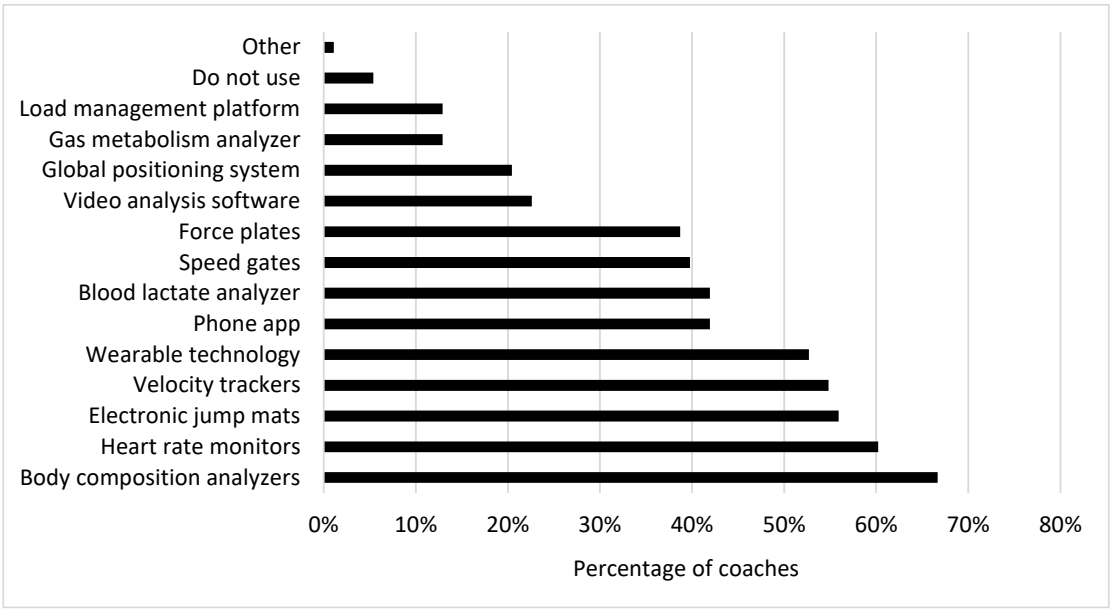

Other
Do not use
Load management platform
Gas metabolism analyzer
Global positioning system
Video analysis software
Force plates
Speed gates
Blood lactate analyzer
Phone app
Wearable technology
Velocity trackers
Electronic jump mats
Heart rate monitors
Body composition analyzers
0%
10%
20%
30%
40%
50%
60%
70%
80%
Percentage of coaches

Table 1. Ranking of the five most important exercises used in the strength training programs of strength and conditioning coaches (*n*=93)

Order of importance	Exercises	N	Percentage
1	Clean and derivatives	31	37
	Squat and variations	27	32
	Snatch and derivatives, bench press, depth jump, high pull, vertical jump	3	4
	Box drills, lunge, and variations	2	2
	Others (e.g., clean and jerk)	1	1
2	Deadlift and variations	15	18
	Clean and derivatives	14	17
	Squat and variations	13	16
	Bench press	10	12
	Snatch and derivatives	7	8
	Box drills	5	6
	High pull	4	5
	Medicine ball throw, vertical jump	3	4
	Pull up	2	2
	Others (e.g., push press)	1	1
3	Squat and variations	12	15
	Clean and derivatives	10	12
	Bench press, deadlift, and variations	7	9
	Pull up, medicine ball throw	6	7
	Bench pull, push-ups, and variations	4	5
	Vertical jump, box drills	3	4
	Clean and jerk, snatch and derivatives, high pull, push press	2	2
	Others (e.g., Hip thrusts, sprints)	1	1
4	Snatch and derivatives	10	12
	Bench press	9	11
	Clean and derivatives, squat and variations	7	9
	Deadlift and variations, pull up	5	6
	Box drills， medicine ball throw	4	5
	Depth jump	3	4
	Hip thrusts, bench pull, hops, vertical jump, loaded jump,	2	2
	Others (e.g., leg press)	1	1
5	Deadlift and variations	9	12

	Snatch and derivatives	7	9
	Clean and derivatives	6	8
	Bench press, squat and variations, clean and jerk	5	6
	Medicine ball throw, pull-up, upper body push, hamstring curl	4	5
	Hip thrusts, depth jump	3	4
	Rowing, bar dip, box drills, kettlebell training, vertical jump	2	3
	Others (e.g., bench pull)	1	1

Note: Variations and derivatives were added when multiple types of the same exercise were reported (e.g., squat, overhead squat, front squat).

Table 2. Percentage of responses from SCCs (*n*=84) for recovery time prescribed between different modes of training, sports training, and competition.

Question	On the same day	24h	36h	48h	>48h
Recovery time between speed development and sports training sessions	27	45	17	8	2
Recovery time between strength/power development sessions and sports training sessions	21	33	15	26	4
Recovery time between speed development sessions and competition	10	32	19	21	18
Recovery time between strength/power development sessions and competition	5	22	19	30	24

Note: Only strength and conditioning coaches who arranged strength, power, and speed training was permitted to answer this question.

Table 3. Percentage of responses from strength and conditioning coaches (*n*=87) for the frequency in which different methods of flexibility training are used.

Type of stretch	Never	Sometimes	Commonly
Dynamic	1	8	91
Static	1	16	83
Proprioceptive Neuromuscular Facilitation	6	55	39

Table 4. Strength and conditioning coach (*n*=91) responses to the unique aspects of their strength and conditioning programs.

Rank	Theme	Exemplar responses	Percentage
1	Nothing	"Nothing"	37
2	Sport-specific	"Carefully analyze sports–specific physical needs, and according to the characteristics of accurate training plan and content" and "design training exercises according to sports features"	19
3	Types of exercises/specific arrangement	"Diversity of training methods" and "explosive training, high–intensity interval training"	18
4	Individualization	"Design training depends on individual differences of athletes" and "establishing a force mode suitable for athletes"	15
5	Psychology	"Stimulate the enthusiasm of athletes training" and "in addition to the normal physical training, sometimes arrange mindfulness exercises for athletes, and carry out 10–15min of imagery training in morning exercises"	9
6	Miscellaneous	"Training according to instructions, requiring uniformity" and "focus on practicality and efficiency, training the most useful quality that can be improved in the limited time"	8
7	Periodization	"Designing a training plan for the improvement of competitive ability according to the characteristics of the sports, the stage task of training and the characteristics of the athletes" and "periodic training plan design according to competition time point and sports specific training"	5
8	Schedule	"Formulating athletes' basic and specific physical tests scheme based on sports specific competition load intensity" and "guide athletes carefully and patiently and plan out the physical abilities that need to be strengthened and improved at each stage"	3
9	Data	"Use digital monitoring training plan and time" and "arrange training plan according to test data and sports specific requirements"	2

Table 5. Strength and conditioning coach (*n*=91) responses to the biggest issues

Rank	Theme	Exemplar responses	Percentage
1	Colleague relationship/ opinion differences	"Most head coaches are still based on experience, and it is difficult to carry out scientific training and related discussions" and "head coach's planning arrangements are unreasonable"	24
2	Nothing	"Nothing"	19
3	Lack of facilities/ equipment/staffing	"Facilities and equipment are limited, so cannot use more means to stimulate the overall physical fitness of athletes" and "training venues are too old, and the new venues do not fully meet the physical training needs, while the lack of practical testing equipment"	12
4	Miscellaneous	"Coaches, parents, and athletes eager for success" and "conflict between training plan and reality"	10
5	Individualization of training	"There are too many football players, so it is difficult to train individually" and "individual differences in collective sports, such as different athletes under the same heart rate fatigue reaction difference are too large"	7
6	Athlete adherence	"Athletes can't execute plans well"	7
7	Sports specific	"How to make physical training more suitable for sports" and "sports specific strength and conditioning training design"	7
8	Job	"Work content messy" and "the position of professional role in system is not clear"	5
9	Time	"Due to the long training of sports, athletes have great fatigue and no motivation for physical training; the timing of physical training classes is uncertain" and "ratio of specific training and physical training"	5
10	Injury	"Training of injured athletes needs to be strengthened" and "athletes injured"	5
11	Monitoring	"Athlete physiological and biochemical indicators test less and not fixed, so coaches cannot well monitor the athletes before and after the physiological indicators" and "monitoring is not accurate enough"	3
12	Knowledge	"Knowledge update is not timely" and "rehabilitation training learning is not enough, such as athletes appear some parts of the discomfort, I cannot handle well"	3

13	Periodization	"Temporary change of long–term plan" and "combination of training content and periodization"	2

Table 6. Strength and conditioning coach (*n*=89) responses to changes or modifications they would make to their programs given unlimited time and resources.

Rank	Theme	Exemplar responses	Percentage
1	Monitoring/testing/equipment/facility	"Enough space, everyone has training equipment, intuitive and scientific monitoring of training" and "I want training to be fully digital"	30
2	Do not change	"Don't want to change"	30
3	Periodization	"Training plan designed according to training stage and characteristics of athletes" and "determine the game time, so as to around the game plan periodical training"	11
4	Training content/method	"Mainly equipment training", "knowledge teaching, body teaching and special ability teaching" and "add more functional training"	10
5	Integration of science and technology	"Combine research and a more scientific team" and "scientific monitoring, scientific training, good feedback" and "scientize"	10
6	Individualization	"Exploring the suitable training mode for each key athlete" and "strengthening individual targeted training design"	9
7	Miscellaneous	"Change according to the actual situation of training" and "take the athletes to the national team to feel the high level of training"	7
8	Time	"Increase the training sessions of athletes" and "batch training changed to unified training"	7
9	Staff team	"Hope to have a professional strength and conditioning, strength, rehabilitation team" and "establish a complete and scientific sports specific strength and conditioning training team system"	6
10	Sports specific	"According to the requirements of the head coach and in line with safety regulations" and "based on the needs of competition"	5

Table 7. Strength and conditioning coach (*n*=80) responses to what they believe future trends in strength and conditioning will be.

Rank	Theme	Exemplar responses	Percentage
1	Digitization/monitoring	"Depends on sports features and data" and "the data obtained by the test can be directly reflected on the tablet or mobile phone, and the data of the athletes can be analyzed by the computer" and "combination of digital training and philosophy theory"	39
2	Integration of science and technology	"Training content should be scientific, strict control of training details and quality, while focusing on training consumption and recovery issues" and "virtual reality, 6g, artificial intelligence, nanorobots, genetic technology"	25
3	Individualization	"Everyone's training plan is unique"	15
4	Staff team	"Compounded coaching team, coaches and athletes collaborate more closely" and "The division of labor in the team is more refined"	15
5	Miscellaneous	"Breaking through the old strength training thought" and "athletes self–training"	14
6	More normal/more important/more demands	"Strength and conditioning will be an important training content, to improve the performance of high–level athletes play a decisive factor" and "improve physical function and fitness to meet a variety of needs"	14
8	Sports specific	"Strength and conditioning training helps further enhance the sports competitive level" and "sports specific strength and conditioning training"	10
9	Job	"Really like a coach. Traditional special coaches will gradually withdraw from the stage of history, a new group of special coaches can better accept our fitness coach" and "role as a scientific assistant, strength and conditioning as the foundation"	8
10	Prehabilitation/injury reduction	"Extending athletes professional life, reducing the pain of injury during their careers after retirement" and "injury prevention"	4

11	Comprehension	"Systematization of training" and "overall improvement of physical ability" and "all–round help into training (special, psychological, rehabilitation, etc.)"	4