Strength and Conditioning and Concurrent Training Practices in Elite Rugby Union

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Abstract

Jones, TW, Smith, A, Macnaughton, LS, and French, DN. Strength and Conditioning and Concurrent Training Practices in Elite Rugby Union. J Strength Cond Res 30(12): 3354–3366, 2016—There is limited published research on strength and conditioning (S&C) practices in elite rugby union (RU). Information regarding testing batteries and programme design would provide valuable information to both applied practitioners and researchers investigating the influence of training interventions or preperformance strategies. The aim of this study was to detail the current practices of S&C coaches and sport scientists working in RU. A questionnaire was developed that comprised 7 sections: personal details, physical testing, strength and power development, concurrent training, flexibility development, unique aspects of the programme, and any further relevant information regarding prescribed training programmes. Forty-three (41 men, 2 women; age: 33.1 ± 5.3 years) of 52 (83%) coaches responded to the questionnaire. The majority of practitioners worked with international level and/or professional RU athletes. All respondents believed strength training benefits RU performance and reported that their athletes regularly performed strength training. The clean and back squat were rated the most important prescribed exercises. Forty-one (95%) respondents reported prescribing plyometric exercises and 38 (88%) indicated that periodization strategies were used. Forty-two (98%) practitioners reported conducting physical testing, with body composition being the most commonly tested phenotype. Thirty-three (77%) practitioners indicated that the potential muted strength development associated with concurrent training was considered when programming and 27 (63%) believed that strength before aerobic training was more favorable for strength development than vice versa. This research represents the only published survey to date of S&C practices in northern and southern hemisphere RU.

Key Words combined exercise, interference, physical preparation, programme design, questionnaire

Introduction

Rugby union (RU) is a contact team sport that is popular worldwide. Match analysis has indicated that RU is a multidirectional, intermittent, invasion game incorporating multiple high-intensity efforts. These vary in nature and consist of sprinting, accelerations, and sport-specific activities including tackling, rucking, mauling, and scrumming (12,13,30,33). The physical demands of RU are specific to the individual positions (24). A 15-player side consists of forwards (n = 8) and backs (n = 7), the forwards are further subcategorised in to; “front row,” “second row,” and “back row” positions. Backs also are subcategorized into “half backs,” “centers,” and “outside backs.” In many cases, players are allocated to certain positions based on their anthropometric and physical performance characteristics, with forwards tending to be heavier and stronger and backs tending to be leaner and faster (11).

A growing body of research has examined the physical demands of competitive RU matches through performance, time motion, and global position system analyses (8,9,33). More recent research has examined the influence of standardized and controlled conditioning interventions on physical performance phenotypes associated with successful RU performance (1,3,42). In addition, studies have investigated the influence of preperformance strategies including postactivation potentiation and hormonal priming on physical performance factors necessary for effective RU performance (2,18,26).

The availability of the literature quantifying both the physical demands of elite RU and the influence of conditioning interventions has allowed practitioners to gain a greater understanding of the physiology of RU and potentially programme more effectively for their athletes. Despite this increased understanding, RU remains a challenging sport to support. In contrast to many
(particularly Olympic) sports, RU requires differing and in some cases contrasting physical qualities for successful performance. Research has indicated that strength and power (both absolute and relative to body mass) are important physical qualities in elite RU union (1,11), in contrast as players can cover an average of ~7 km during a competitive match (8) athletes also require aerobic and fatigue resistance capabilities (33). This required contrast may present practitioners with problems when programming as responses to strength and power training can be muted as a result of endurance type stimulus (21,22,25,28). This inhibited strength development or “interference effect” (22) associated with concurrent strength and aerobic training also warrants consideration during training phases such as preseason, in which practitioners often have limited time to promote gains in strength and power phenotypes.

Despite the growing global profile of RU and increasing attention in the scientific literature, there is little published information available pertaining to practices and strategies used by strength and conditioning (S&C) and sports science practitioners in elite RU. Although S&C practices have been examined in various North American and Olympic sports (10,14–16,19,38), there are no available data detailing how specific conditioning is prescribed and monitored in elite RU. In addition, is it is presently unknown if the “interference effect” associated with concurrent strength and aerobic type training is (a) considered and (b) managed by practitioners working with RU athletes.

Information relating to common trends in training prescription and management could act as a useful reference source for applied practitioners. This information also may inform training programme design for future studies seeking to examine the influence of conditioning interventions in elite RU athletes. As such, the aim of this study was to survey and examine training and monitoring strategies of practitioners responsible for the S&C of RU athletes.

**METHODS**

**Experimental Approach to the Problem**

The survey titled “Strength and Conditioning Questionnaire” was adapted from that used by Ebben and Blackard (14). The questionnaire was made specific to RU and pilot tested on a group of 7 S&C coaches. The survey contained 7 sections: personal details, physical testing, strength and power development, concurrent training, flexibility development, unique aspects of the programme, and any further relevant information regarding prescribed training programmes. The survey was distributed to S&C coaches and sport scientists working with either professional rugby clubs/franchises/provinces or national teams in both the northern and southern hemispheres. It was hypothesized that this study would provide a comprehensive view of S&C and concurrent training practices in elite RU.

**Subjects**

Before all experimental procedures, the Northumbria University research ethics committee approved the study. All subjects were informed of the risks and benefits of the investigation before signing an approved informed consent document to participate in the study. Surveys were sent out electronically through e-mail and a survey collating Web site. Data were collected between September 2014 and February 2015.

**Statistical Analyses**

The survey contained fixed-response and open-ended questions. Answers to open-ended questions were content analyzed according to methods described by Patton (31),
which have previously been used in other surveys of S&C practices in elite and professional sports (10,15,16,38). Researchers had experience with qualitative methods of sports science and S&C research. When analyzing data, investigators generated raw result data and higher-order themes through inductive content analysis and compared individually generated themes until agreement was reached at all levels of analysis. When higher-order themes were developed, deductive analysis was used to confirm that all raw data themes were represented.

**RESULTS**

**Personal Details**

Forty-three (41 men, 2 women; age: 33.1 ± 5.3 years) of 52 (83%) coaches responded to the questionnaire. The respondents consisted of 21 S&C coaches, 12 head S&C coaches, 3 senior S&C coaches, 3 academy S&C coaches, 2 performance managers, and 2 sport scientists. Forty-two practitioners reported having fellow coaching and support staff. Examples of fellow coaching staff given by respondents were “Assistants,” “Interns,” and other S&C staff such as performance managers and “Travelling S&C Coach” (text in double quotes are direct quotations taken from questionnaires). Four practitioners were based in Australia, 3 in France, 4 in New Zealand, 2 in South Africa, 1 in Hong Kong, 1 in Japan, 1 in Samoa, and 27 in the United Kingdom.

![Figure 2. Physical phenotypes tested.](image-url)

**Figure 2.** Physical phenotypes tested.

### Table 2. Sets and repetitions used during in-season programmes.

| Higher-order themes | No. responses | Select raw data representing responses to this question |
|---------------------|--------------|------------------------------------------------------|
| Set range of 3–5    | 24           | “Huge variance depending on the outcome” |
| Set range including >5 sets | 9           | “Neural—less than 3, cellular—to failure” |
| Repetition range of 3–5 | 12          | “Dependent of team and athlete experience” |
| Repetition range including >5 repetitions | 18          | “Depends upon the individual player” |
| Miscellaneous*     | 6            | “Repetition ranges vary hugely based on the individual aims of the programme, training history, loading scheme, etc” |

*Answers that could not be associated with any of the broad identified themes.*
Information on the types of athlete coached by the respondents is presented in Table 1.

**Formal Education**
Seventy-nine percent of respondents had an undergraduate degree in Sport and Exercise Science or a related subject and 61% held a master’s degree in a Sport Science–related field. In addition, 2 coaches held Post Graduate Certificates in Education and 2 stated they were completing PhDs in Exercise Physiology and S&C.

**Certification**
The most commonly held professional certification was United Kingdom Strength and Conditioning Association Accreditation \( (n = 10) \). Nine respondents were certified S&C specialists with the National Strength and Conditioning Association (USA), 5 were accredited at various levels by the Australian Strength and Conditioning Association, and 6 were British Amateur Weightlifting Association certified. Other qualifications held included “British Association of Sport and Exercise Sciences High Performance Sport Accreditation,” “International Society for the Advancement of Kinanthropometry Accreditation,” and “United Kingdom Athletics Coaching Qualification.”

**Physical Testing**
Forty-two of 43 respondents indicated that physical testing was conducted on their athletes. Participants were asked when testing was performed (Figure 1) and what aspects of physical performance were tested (Figure 2). The most commonly used test of acceleration was 10-m sprint time \( (n = 30) \). Tests of agility included proagility test, “reactive agility,” Illinois agility run, T-test, 5-0-5 test, change of direction and acceleration test, and “in depth lateral jumps.” Measures of anaerobic capacity included Rugby Football Union anaerobic test, Welsh Rugby Union WAT test, “repeat sprint ability,” Yo-Yo test, “Watt-Bike repeat sprints \((10 \times 6 \text{ seconds in at } 30\text{-second intervals})\),” “Watt-Bike 30-second sprint,” “Watt-Bike 6-minutes test,” 500-m rowing, phosphate decrement test, “3 × 60-second running test,” “intermittent shuttle test,” anaerobic shuttle, “lactate test on treadmill,” “Bronco shuttle test,” “GPS work capacity,” “Australian 30 seconds × 6 test,” Wingate test, “rugby anaerobic fitness test,” “150-m Shuttle Test," “club-specific conditioning test,” “rugby-specific testing,” “anaerobic training threshold zone (ATTZ) runs,” and “6 × 30-m sprints.”

The most commonly used measure of body composition was sum of 8 site skinfolds \( (n = 22) \) with 7 \( (n = 5) \) and 3 \( (n = 1) \) site skinfolds also utilized. Other measures of body composition included body mass, height, dual-energy x-ray absorptiometry, body fat%, and one respondent designed their own method of assessing body composition, although no other details were given. Twenty-three respondents stated that the Yo-Yo incremental test was utilized as a measure of cardiovascular (CV) endurance, other used tests of CV.

### Table 3. Sets and repetitions used during off-season programmes.

| Higher-order themes | No. responses | Select raw data representing responses to this question |
|---------------------|--------------|---------------------------------------------------------|
| Set range of 3–6    | 22           |                                                        |
| Set range including &gt;6 sets | 6           |                                                        |
| Repetition range of 3–8 | 12          | “During the off-season, we typically use higher volumes” |
| Repetition range including &gt;8 repetitions | 20          | “Dependent of team and athlete "experience and aim of programme” |
| Miscellaneous*      | 2            |                                                        |

*Answers that could not be associated with any of the broad identified themes.

### Table 4. Recovery time prescribed between strength training and rugby training and competitive matches.

| Question | Same day | 24 h | 36 h | 48 h | &gt;48 h |
|----------|----------|------|------|------|----------|
| Time prescribed between Olympic style lifting session and high-quality rugby session | 34 | 9 | 2 | 2 | 1 |
| Time prescribed between general strength session and high-quality rugby session | 31 | 8 | 4 | 5 | 0 |
| Time prescribed between Olympic style lifting session and competitive rugby match | 4 | 6 | 11 | 22 | 9 |
| Time prescribed between general strength session and a competitive rugby match | 1 | 4 | 11 | 20 | 14 |
TABLE 5. Practitioners rank order of the 5 most important weightlifting exercises within their training programme.

| Order of importance | Exercises (no. coaches reporting)                                                                 |
|---------------------|--------------------------------------------------------------------------------------------------|
| 1                   | Squat (30)                                                                                       |
|                     | Clean (9)                                                                                       |
|                     | Any single leg strength variation (1)                                                            |
| 2                   | Clean (19)                                                                                      |
|                     | Deadlift (6)                                                                                     |
|                     | Squat (3)                                                                                        |
|                     | Pull-up and bench press (2)                                                                     |
|                     | Nordics, unilateral lower body, high pull, push press, Romanian deadlift, snatch, hamstring variations, and split squat (1) |
| 3                   | Bench press (7)                                                                                  |
|                     | Olympic lift variation (5)                                                                       |
|                     | Romanian deadlift (4)                                                                            |
|                     | Push press, split squat, and split jerk (3)                                                      |
|                     | Bench pull, squat, overhead press, and horizontal row (2)                                        |
|                     | Chin, single arm row, deadlift, lunge, and dumbbell press (1)                                   |
| 4                   | Chin (8)                                                                                         |
|                     | Push press, deadlift, snatch, and clean (2)                                                      |
|                     | Bench press, bent over row, landmine, power jerk, jump squat, split jerk, squat, high pull, single leg squat, military press, Romanian deadlift, bench pull, weighted step ups, and single leg deadlift (1) |
| 5                   | Bench press (7)                                                                                  |
|                     | Chin (5)                                                                                         |
|                     | Overhead press, clean, bent over row, snatch, and Romanian deadlift (2)                          |
|                     | Floor hip thruster, push press, deadlift, high pull, dumbbell incline press, bench throw, split squat, shoulder rotation, bench pull, and single arm row (1) |

endurance included 1,500-m run, “30-15 aerobic test,” “a 4-minute shuttle test,” 1-km run, “MAS test TUB 2,” “1-km repeat,” “3-min Watt-Bike test,” 2.4-km time trial, “7-minute test,” “modified bleep test,” “Watt-Bike 20-minute test,” “GPS work capacity,” “incremental treadmill test,” “ATTZ test,” and “1.6-km time trial.”

Functional movement screening was the most commonly utilized measure of flexibility (n = 8), other measures of flexibility included “physio screening,” “subjective assessments,” sit-and-reach test, “physical competency assessment,” Thomas test, hamstring capacity, thoracic rotation, knee to wall test, “internally developed movement competency screen,” “range of motion tests,” and overhead squat. Seventeen respondents tested indices of muscular endurance (Figure 2): these included glute bridge, calf raise, max push ups, max sit ups, “modified test involving body weight exercises, and timed run devised around facility layout,” max chins, max dips, max pull-ups, “capacity tests on calves, glutes and hamstrings,” plank, side plank, back extension, and single leg glute bridge.

The most commonly used test of muscular power was maximum countertermovement jump height (n = 19), 11 (26%) practitioners assessed 1–3 repetition maximum (RM) in Olympic lifts (clean or snatch), or their variations (i.e., from hang position), additionally 17 (40%) assessed reactive strength index or other jump variations including broad jumps, drop jumps, squat jumps, “triple response jumps,” etc. A variety of other measures of muscular power were utilized by respondents including “velocity test,” velocities of movements through “GymAware” and “Attacker” systems, 10- and 30-m sprints, tendon stiffness, IRM in bench press, back squat and half squat, “bench throw and pull,” and peak power output in 6 seconds on Watt-Bike and medicine ball throw. Twenty-eight practitioners utilized IRM testing to assess muscular strength with bench press (n = 22) and back squat (n = 20) the most common lifts. Other methods of assessing muscular strength included mid-thigh isometric pulls on a force plate and “predicted RMs taken from strength training performance.” All 37 respondents who stated that testing speed phenotypes examined sprint times with distances ranging from 10 to 80 m, additional speed tests used included “speed bounce” and GPS maximum velocity.

Strength and Power Development

The initial question in the section asked if practitioners believed that strength training benefits RU performance, all 43 respondents answered yes. Eight practitioners left additional comments such as “stronger players are more resilient,” “it helps the players develop the appropriate physical qualities that are required to play the game,” “But a focus on quality of lifting through a full range if safe for the athlete is critical as well as the combination of movement skills, awareness and integration with the rest of the rugby programme is critical to maximum carryover into performance” and “it is a very important part of preparation but in my experience it’s importance is overstated by the rugby community.” All 43 respondents also stated that strength training was regularly performed by their athletes.

In-Season Training

The current section was divided into 2 subsections, the first of which focused on in-season strength and power training practices. The first question in this subsection asked how many days of the week that in-season strength and power training was performed; 1 practitioner reported 1 d·wk$^{-1}$,
14 reported 2 d·wk⁻¹, 35 reported 3 d·wk⁻¹, 4 reported 4 d·wk⁻¹, and 1 reported 5 d·wk⁻¹.

The second question within this subsection asked coaches to detail the days of the week in which strength and power training is performed in relation to next scheduled match day (MD); 6 practitioners reported MD-6, 31 reported MD-5, 36 reported MD-4, 14 reported MD-3, 35 reported MD-2, 6 reported MD-1, and 3 reported strength and power training was conducted on MD. The third question in this section asked practitioners the typical duration of an in-season strength and power session; 2 practitioners reported 15–30 minutes, 12 reported 30–45 minutes, 26 reported 45–60 minutes, and 7 reported 60–75 minutes. The final question in the subsection asked practitioners to indicate the number of sets and repetitions typically used for strength training exercises in-season. Responses were content analyzed and resulted in the creation of 5 higher-order themes including (a) set range of 3–5, (b) set range including >5 sets, (c) repetition range of 3–5, (d) repetition range including >5 repetitions, and (e) miscellaneous. Further information on higher-order themes, practitioner responses, and representative raw data is presented in Table 2.

### Off-Season Training

The first question in the off-season subsection asked practitioners the number of days per week their players engage in strength training. Three practitioners reported 2 d·wk⁻¹, 11 reported 3 d·wk⁻¹, 25 reported 4 d·wk⁻¹, 10 reported 5 d·wk⁻¹, and 4 reported 6 d·wk⁻¹. The following question addressed the average length of an off-season strength/power session; 2 respondents reported 15–30 minutes, 4 reported 30–45 minutes, 22 reported 45–60 minutes, 12 reported 60–75 minutes, and 1 reported >75 minutes.

The final question in the off-season training subsection asked practitioners to indicate the number of sets and repetitions typically used for strength training exercises during the off-season. Content analysis resulted in the creation of 5 higher-order themes including (a) set range of 3–6, (b) set range including >6 sets, (c) repetition range of 3–8, (d) repetition range including >8 repetitions, and (e) miscellaneous. Further information on higher-order themes, practitioner responses, and representative raw data is presented in Table 3.

### Programme Design

The initial question in this subsection asked whether practitioners included Olympic style weightlifting exercises in their prescribed training programme. Thirty-eight respondents indicated that Olympic style weightlifting exercises were included in conditioning programmes.

The next questions within this subsection were related to

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**Table 6. Determination of training loads.***

| Higher-order themes                  | No. responses | Select raw data representing responses to this question |
|--------------------------------------|---------------|--------------------------------------------------------|
| RM and max strength testing          | 31            | Percentage of 1RM. All % based from preseason testing. % of a 1–3RM test. |
| Athlete lead                         | 3             | Athlete lead, occasional last set max repetitions of weight used to see if appropriate weight. Players determine their own weights based on how they physically feel. |
| Coaches subjective assessment        | 3             | Coaching eye, then prescribed in vital training blocks. Assessment of the required effort vs. technical breakdown/quality. |
| Periodization and phase of training  | 3             | Current needs and stage of season. Consideration given to current aims of programme and training history. |

*RM = repetition maximum.

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**Table 7. Training methods used by coaches for speed development.**

| Higher-order themes                  | No. responses | Select raw data representing responses to this question |
|--------------------------------------|---------------|--------------------------------------------------------|
| Unresisted (free) sprinting          | 25            | Actual max speed running. Sprinting on a track. Free sprinting. |
| Plyometrics                           | 13            | Pyllos. Plyometrics. Plyometric movements. |
| Sprint mechanics and technique       | 13            | Running mechanics. Technical delivery. Technique development. |
| Resisted sprinting                   | 13            | Weighted sleds. Resisted accelerations. Sled and Bungee cord work. |
| Improving max strength               | 9             | Max strength development. Increasing strength and power through weight training. Creating a high strength base. |
| Olympic lifts                        | 4             | Olympic lifts. Hang cleans. |

Many respondents detailed more than 1 training method.
recovery time prescribed between (a) an Olympic weightlifting style strength session and a high-quality rugby training session, (b) a general strength training session and a high-quality rugby training session, (c) an Olympic weightlifting style strength session and a competitive rugby match, and (d) a general strength training session and a competitive rugby match. Responses to these 4 questions are detailed in Table 4. Practitioners were then asked the extent to which they agreed that strength and power training influenced rugby performance; 26 coaches indicated that they strongly agreed, 14 strongly agreed, and 1 indicated they were unsure. The next question asked coaches to identify and rank the top 5 weightlifting exercises that are most important in their programmes, responses to this question are detailed in Table 5.

Question 7 in this subsection asked practitioners if they used periodization strategies to structure training plans. Thirty-eight (88%) respondents indicated that periodization strategies were used. Practitioners comments in response to this question included “To target specific outcomes in a specific period,” “Better long-term results, prevents stagnation,” and “Monitoring and assessing load and volume with intensity is vital, so you need to know when to delay and load at appropriate times of the year.”

The final question in this section asked practitioners how load (weight) was determined during typical strength training sessions. Responses were content analyzed into 4 categories including (a) RM and max strength testing, (b) athlete led, (c) coaches subjective assessment, and (d) periodization and phase of training. Data pertaining to higher-order themes, total number of practitioners whose responses made up the theme and selected raw data within higher-order themes, are presented in Table 6.

**Speed Development**

Forty of 43 (93%) respondents who completed the survey reported incorporating aspects of speed development in their programming. Responses were content analyzed and resulted in the creation of 6 higher-order themes: (a) unresisted (free) sprinting, (b) plyometrics, (c) sprint mechanics and technique, (d) resisted sprinting, (e) improving max strength, and (f) Olympic lifting. Table 7 details the aforementioned higher-order themes, the total number of coaches whose responses made up the theme, and select raw data within each higher-order theme.

**Plyometrics**

Forty-one (95%) respondents reported using plyometrics. The subsequent question in this section asked why coaches prescribed plyometrics, 16 (37%) coaches reported prescribing plyometrics for improving rate of force development, 7 (16%) for training the stretch shortening cycle, 4 (9%) for improving stiffness, and 2 (5%) for injury prevention. The third question in this subsection asked practitioners which phases of the year

**TABLE 8.** Methods of integration of plyometrics into prescribed training programme.

| Higher-order themes | No. responses | Select raw data representing responses to this question |
|---------------------|--------------|------------------------------------------------------|
| Within strength and/or power session | 25 | Within strength programme. Mainly in strength/power sessions. With strength or Olympic lifts. |
| Dependant on individual athlete | 4 | Individually based around the needs of the athlete. Depends on individual. |
| Within warm up | 2 | Part of warm-up. Part of field warm-ups in-season. |
| Part of movement skills | 1 | Part of movement skills. |
Plyometrics are used; Figure 3 illustrates the responses to this question.

The fourth question in this subsection examined integrated plyometrics. Responses were content analyzed and resulted in the creation of 4 higher-order themes; (a) within strength and/or power session, (b) dependant on Individual athlete, (c) within warm-up and (d) part of movement skills. Table 8 lists the higher-order themes, number of practitioners whose responses make up the theme and representative raw data within each theme. The final question within this subsection asked practitioners to identify types of plyometric exercises regularly used in their programme. Responses to this question are detailed in Figure 4.

**Flexibility Development**
Forty-one (95%) practitioners indicated that some form of flexibility training was included in players’ physical programmes. Thirty (70%) respondents indicated that static stretching was performed, 26 (60%) reported using proprioceptive neuromuscular facilitation and 37 (86%) indicated that dynamic stretching was performed. Six (14%) respondents reported using other methods of flexibility development including yoga, body balance, band distraction, and stretch bands. The following question asked practitioners when their athletes performed flexibility exercises; the typical duration of flexibility sessions and the duration athletes were encouraged to hold a static stretch. Results from these questions are presented in Figures 5–7.

**Concurrent Strength and Endurance Training**
The first question in the subsection asked practitioners if
they considered any potential muting effect of endurance training on strength/hypertrophic development, 33 (77%) practitioners indicated that they did and 8 (19%) indicated that they did not. Reasons for not considering any potential interference effect consisted of “Rugby is concurrent,” “Players must develop both motor qualities,” and “If programmed correctly can balance both into programmes.”

The following question in this subsection asked practitioners how important they felt it was to consider any concurrent training effect when programming for strength/hypertrophic development (1 = not important at all and 5 = most important), the responses to this question are detailed in Figure 8. The penultimate question asked participants to rank the following programme variables in order of importance when attempting to avoid any muting effect of endurance type stimulus on strength/hypertrophic development; periodization, order of strength and endurance training, volume of endurance training, volume of strength training, and time between strength and endurance training. Responses to this

| Programme variable                                      | Order of importance, 1 = most important, 5 = least important (no. responses) |
|----------------------------------------------------------|--------------------------------------------------------------------------------|
| Periodization                                            | 18 4 3 3 11                                                                    |
| Order of strength and endurance training                 | 11 11 9 7 1                                                                     |
| Volume of endurance training                             | 6 12 11 6 4                                                                    |
| Volume of strength training                              | 2 2 8 16 11                                                                    |
| Time between strength and endurance training             | 2 10 8 7 12                                                                    |
question are detailed in Table 9. The final question in this section asked practitioners which order of strength and endurance training they felt was more conducive to strength and/or hypertrophic development, 27 (63%) practitioners believed that strength then endurance training was more favorable and 12 (28%) believed endurance then strength.

Unique Aspects of the Programme
The unique aspects (if any) of practitioners physical conditioning were content analyzed and divided into 5 higher-order themes: (a) individualization, (b) nothing unique, (c) miscellaneous, (d) integration, and (e) periodization. Table 10 details these themes and the number of practitioners’ responses that make up each theme. The second question within this section asked practitioners what they would like to do differently in their conditioning programmes. Responses were content analyzed and resulted in the creation of 6 higher-order themes; (a) have more time, (b) miscellaneous, (c) improved facilities/equipment, (d) greater individualization, (e) improved monitoring, and (f) more staff. Table 11 details these themes and the number of practitioners’ responses that make up each theme.

DISCUSSION
The present study sought to conduct a comprehensive survey of S&C and concurrent training practice in elite RU. To the authors’ knowledge, this is the first qualitative assessment of practitioners S&C practices in RU. A total of 43 practitioners responded to the questionnaire, this is the highest number of responses obtained in a study examining S&C provision in a single sport. Previous studies examining S&C practices in North American sports have received between 20 and 26 responses (14–16,38) and a more recent study in British Rowing received 32 responses (19). The response rate to our survey was high (83%), previous comparable studies have reported return rates of between 69 and 87%. As such, 43 responses at a return rate of 83% were deemed sufficient for analysis. Many respondents stated that they worked with more than 1 level of RU athlete. The most commonly supported level of athlete played for either a professional club, province or franchise, and/or a national team (30 and 24 responses). Therefore, the data presented in this article are reflective of elite RU.
Practitioners reported testing 11 aspects of physical fitness (additional are details presented in Figure 2). This number is notably more than previously reported in other sports including Major League Baseball (MLB) (3–4 aspects) (16), National Hockey League (NHL) and National Basketball Association (NBA) (7–8 aspects) (15,38), and Rowing (4–5 aspects) (19). The 11 aspects of physical fitness tested in the present study are, however, similar to that previously reported in National Football League (NFL) (9–10 aspects) (14). It is possible that this is reflective of the similarities between RU and NFL as they are both contact, intermittent, invasion based team sports. However, comparisons should perhaps be interpreted with caution as Ebben and Blackard (14) reported S&C practices in NFL in 2001 and it is very likely that assessment batteries in NFL have progressed and been adapted over the past ~14 years.

The most commonly tested aspect of physical fitness was body composition, which was assessed by 40 of 42 (95%) of practitioners. Similarly, body composition was commonly assessed by practitioners working with North American sports with 83–100% of respondents indicating body composition was assessed (14–16,38). To the authors’ knowledge, there are no empirical data demonstrating that “favourable” changes in body composition (increased lean mass and lower levels of subcutaneous fat) result in improved RU performance. However, when % body fat from separate studies are combined, a linear relationship between playing standard and % body fat is evident and it seems that as playing standard increases, % body fat of RU athletes decreases (full summary provided by Duthie et al. (11)). It is also reasonable to suggest that increases in lean mass and reduction in % body fat may result in improvements power to body mass ratio, acceleration, and other performance phenotypes associated with RU performance. Monitoring body composition may also be useful for assessing (any) gains in lean mass following any prescribed hypertrophy type training. Other commonly assessed aspects of physical fitness were max speed, muscular power (both 37), acceleration, and muscular strength (both 36). It is likely this indicates the practitioners who responded to the survey consider these physical qualities important for RU performance. There was a notable variance in measures of anaerobic capacity employed, with 17 different measures used across the 31 practitioners who indicated that they performed anaerobic capacity testing. This may indicate that there is a need for future work to construct a valid and standardized protocol for assessing anaerobic capacity in RU athletes. Overall physical testing was most commonly conducted pre- and in-season with 41 and 38 respondents indicating that physical testing was conducted during these phases.

All 43 respondents indicated that strength training was regularly performed by their athletes; in addition, all practitioners believed that strength training is beneficial for RU performance. This belief is supported by research indicating that RU performance requires high levels of contractile strength (29,35). Thirty-eight of the 43 practitioners (90%) reported implementing Olympic style weightlifting exercises within strength and power training. This practice is similar to those reported in Rowing (87% of practitioners surveyed), NFL (88%), NBA (95%), and NHL (91%) (14,15,19,38). These data indicate that Olympic style weightlifting exercises are widely prescribed in team sports and rowing, this prescription is most likely due to the association with Olympic lifting training and improvement in power output and acceleration (5,41) which have been identified as important physical qualities in RU and other sports (33,37). The squat and clean were considered the most important exercise within players training programmes. The aforementioned lifts were seen also as the 2 most important by practitioners working in Rowing, NBA, NFL, and NHL (14,15,19,38).

With regard to strength training frequency, 35 (81%) practitioners reported prescribing strength training 3 d·wk\(^{-1}\) in-season, whereas in the off-season 25 (58%), practitioners reported prescribing strength training 4 d·wk\(^{-1}\). The most common set/repetition/load scheme prescribed in-season was 3–5 sets of >5 repetitions based on RM and max strength testing, this scheme differed to the most common prescription of 3–6 sets of >8 based on RM and max strength testing. This increased volume of strength training also was reflected in practitioners’ comments which included “during the off-season, we typically use higher volumes.” These alterations in strength training volume may reflect the shift of conditioners focus from maintenance (in-season) to development (off-season) of physical qualities and that S&C staff tend to have more contact time with athletes outside the competitive season (anecdotal observations and reports from practitioners).

Speed development training was prescribed by 40 respondents (93%), which is similar to that reported in NFL, MLB, NBA (all 100%), and NHL (96%) (14–16,38). Unresisted or “free” sprinting was the most popular method of speed development, training methods included “max speed running” and “track sprinting.” The second most popular method of speed development was plyometrics and 41 (95%) respondents reported implementing plyometrics within their conditioning plans (for speed development or otherwise). As with speed development, this method is similar to NBA (100%), MLB (95%), and NHL (91%) (15,16,38). It is somewhat surprising that the prevalence of plyometrics prescribed in NFL was notably lower (73%) (14) than that in RU given that both sports require physical qualities such as power and acceleration for successful performance (4). However, as previously stated, it is likely that S&C practices in NFL have changed since the study of Ebben and Blackard (14) was conducted.
Thirty-eight of 43 respondents (90%) reported implementing periodization strategies in their conditioning programmes, this practice is similar to that of coaches in Rowing (97%), NBA (91%), NHL (90%), and MLB (83%) (15,16,19,38). Periodization strategies have been demonstrated to result in greater improvements in strength, power and body composition than linear training (27,40). Periodization has also been reported to be an effective means of avoiding any potential muting effect of aerobic type stimulus on strength and power development (17). Thirty-three respondents (77%) indicated that the “interference effect” associated with concurrent strength and aerobic training was considered whilst programming for RU athletes. In addition, 20 (47%) practitioners believed that it was very important to consider when constructing conditioning plans. As previously stated, periodization has been reported to be an effective means of concurrently developing strength and aerobic physical qualities (17), as such it is perhaps unsurprising that periodization was ranked as the most important programme variable when attempting to avoid any interference effects (Table 9). Time between strength and endurance training was considered the least important variable to consider. This finding is somewhat surprising as research has indicated allowing sufficient time (≥6 hours) between strength and aerobic stimuli allows strength development to occur uninhibited (17,34). In addition, elite Kayakers have been reported to separate strength and aerobic training sessions by 6–8 hours to allow full glycogen restoration (17). The majority of practitioners scheduled strength and Olympic lifting sessions (72 and 79% respectively) on the same day as high-quality RU sessions; however, the recovery period afforded between sessions was not detailed.

Twenty-seven (63%) practitioners believed that strength before endurance training was more conducive to strength development rather than vice versa. Researchers have reported similar magnitudes of strength development when strength training is conducted prior endurance training and vice versa (6,20,36). However, Collins and Snow (7) reported maximal strength development was greater when strength training was conducted subsequent to endurance training rather than vice versa. In contrast, it has been reported that in well-trained individuals, strength training performance is lessened for up to 8 hours after aerobic type training (39), which over time may result in muted strength development. As such, it presently remains unclear which order of concurrent strength and aerobic training is most favorable for strength development and how it should be programmed in sports such as RU, which require both strength and aerobic physical qualities.

From analysis of survey data, key research findings emerged. Physical testing was commonly conducted amongst practitioners with body composition, max speed, muscular power, and strength and acceleration being the most commonly tested variables. Olympic lifting was widely prescribed within strength training and most practitioners used periodization strategies when programming. Most respondents consider the interference effect associated with concurrent strength and aerobic training and many believed that it was an important factor to consider whilst programming. Periodization was identified as the most common programme variable to consider when attempting to avoid any muting effect of endurance stimulus on strength/hypertrophic development, whereas time between strength and aerobic stimuli was considered the least important. With further regard to concurrent training, most practitioners believed that strength before endurance training was more favorable for strength development than vice versa. Unresisted/free sprinting was the most popular method of speed development, and plyometrics were the second most popular. Plyometrics were also prescribed by almost all practitioners for the development of physical qualities such as speed, power, and acceleration.

**Practical Applications**

This study describes S&C and concurrent training practices of practitioners supporting RU athletes in the Northern and Southern hemispheres. As most respondents supported international and/or professional level RU athletes, practitioners now have a source of data describing S&C practices at the elite end of RU. Coaches and sports science practitioners who work with RU athletes at all levels of the game may use this summary of S&C practices as a resource to inform and improve their practices. Information presented in this article may also influence the design of experimental protocols in future studies investigating effects of conditioning interventions on physical performance phenotypes associated with RU performance.

**Acknowledgments**

The authors thank all individuals who volunteered to participate in the study. The results of the present study do not constitute any endorsement from the National Strength and Conditioning Association.

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