A Field-Based Fitness Testing Battery for Rugby League

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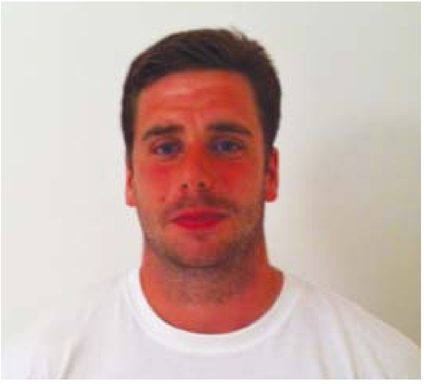

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Introduction

Rugby league football originated in the north of England in the 1890's and is now played globally. Participating nations in the southern hemisphere include Australia, New Zealand, Papua New Guinea, Fiji and Samoa, with only the British Isles (England, Scotland, and Wales), Ireland, and France representing the Northern Hemisphere. Currently, little data exists regarding the physical demands of professional rugby league, with evidence being solely represented through sub-elite[10] and junior players.[18] This knowledge however, is fundamental when designing strength and conditioning programmes and specific to this article, fitness testing batteries.

Therefore, the purpose of this article is two fold. Firstly, to conduct a needs analysis of rugby league and thus identify the fundamental fitness parameters. Then secondly, compare and contrast tests deemed suitable to assess these and from which a testing battery will be advised. The fitness testing battery will also be considered based on the practical experience gained from working with professional rugby league teams. This is an important step in bridging the gap between the theory and application of sport science, whereby the constraints of the work place can also be commented on.

Needs Analysis: What Should Be Tested?

Arguably, as part of any needs analysis, there are generic physical parameters that should be defined in the context of the sport in question. These are anthropometry (height, weight and body fat percentage), aerobic capacity, speed (encompassing acceleration and top speed) and speed-endurance, agility, strength, power and reactive strength (i.e., the ability of the athlete to utilise the stretch-shortening mechanism). These parameters are therefore discussed overleaf.

Anthropometry

The measurement of an athlete's body composition helps regulate non-functional mass. Rugby league players have been shown to have a higher body mass than other team sports, such as soccer and Australian rules,[34] with elite players having a higher percentage of body fat than sub-elite players.[23] This however, should not be considered a desirable characteristic as a higher percentage of body fat adds non-functional weight, reducing acceleration (by increasing inertia), increasing energy expenditure[32] and negatively affecting power to body mass ratio, thermoregulation and aerobic capacity.[18]

Gabbett, Kelly and Pezet[23] reported no significant difference between first, second and third grade players when comparing height, body weight and skinfold thickness. Thus currently, the ability to generalise playing level via anthropometric values appears improbable. Furthermore, elite junior starters are suggested to have greater skinfold thickness (millimetres) than non-starters (68.5 ± 13.6 vs. 64.3 ± 17.6 respectively). The large standard deviations are suggestive of discrepancies between players, and may be indicative of other attributes predetermining elite status in the current game. Nevertheless, in the opinions of the authors, this is still an important determinant of performance.

Because the direct assessment of body composition (e.g., DEXA scanning) can be impractical for testing large squads of players, indirect methods

Table 1. Physiological and anthropometric characteristics of first-grade, second-grade, and third-grade rugby league players.[23]

Variable	**First Grade (n=26)**	**Second Grade (n=40)**	**Third Grade (n=20)**
Age (y)	23.7 ± 4.3	24.4 ± 5.0	17.8 ± 1.5
Playing Experience (y)	16.3 ± 6.7	14.3 ± 7.3	9.4 ± 4.3
Body mass (kg)	92.2 ± 11.4	88.9 ± 9.0	81.5 ± 20.2
Height (cm)	179.0 ± 7.3	180.1 ± 5.2	177.6 ± 7.9
Skinfold Thickness (mm)	44.0 ± 10.1	40.3 ± 11.8	37.4 ± 15.9
10m Sprint (s)	2.06 ± 0.18	2.12 ± 0.19	2.09 ± 0.26
20m Sprint (s)	3.36 ± 0.23	3.44 ± 0.22	3.44 ± 0.27
40m Sprint (s)	5.83 ± 0.31	5.92 ± 0.35	5.96 ± 0.38
Agility	5.90 ± 0.19	6.25 ± 0.52	6.25 ± 0.48
Vertical Jump	50.7 ± 9.8	45.2 ± 8.4	44.3 ± 11.9
Estimated VO_{2max} (ml/kg/min)	46.9 ± 5.8	45.6 ± 5.7	45.6 ± 7.6

(normally via skinfold measurements), are commonly implemented and have been found to positively correlate to DEXA results (gold standard).[15] The guidelines for testing skinfold thickness are highlighted by ACSM[1] and illustrated in *Table 2*. The 3 and 7 site procedures have a standard error of measurement difference of 0.01% (although no difference for males), thus it appears prudent to select the 3 site for field based testing to increase time efficiency with marginal error.

Aerobic Capacity

The metabolic conditioning of a team sports player serves a crucial role in defining and ultimately limiting their contribution in a game.[26] Rugby league places a significant demand on aerobic metabolism and duly requires high levels of aerobic fitness.[18,21,32] A rugby players' fitness level is suggested to be indicative of playing level,[3,17,19] with match intensity increasing linearly with playing standard.[17] Furthermore, this is linked to their ability to exhibit high levels of skill under pressure and fatigue.[20,23] Gabbett, Kelly and Pezet[23] reported that professional rugby league players have a VO_{2max} of 46.9ml/kg/min (*Table 1*), whereas Coutts *et al.*,[10] reported a higher VO_{2max} value of 57.9 ± 3.6 ml/kg/min. Furthermore, matches are played with a mean intensity of approximately 81.1 ± 5.8% of VO_{2max}, which is close to lactate threshold (LT), or 80–90% of HR_{max}.

It is apparent therefore, that the aerobic capacity of a rugby league player should be adaquately developed to withstand the rigours of competition and consequently be assessed during a macrocycle. The 'gold standard' test for assessing aerobic fitness is the direct measurement of a player's maximal oxygen uptake (VO_{2max}) whilst running to exhaustion on a treadmill in the laboratory. Of course, laboratory procedures demand significant time, expense and resources. Indirect field based testing is therefore often employed and aims to measure VO_{2max} through quantifying either the athletes time to finish a set distance, or time to exhaustion through incremental or continuous testing. Research quantifying the aerobic capacity of rugby league players is limited, thus empirically similar sports (i.e. soccer and rugby union) need to be utilised to enable comparisons. For these sports, the Yo-Yo intermittent test is usually the test of choice to measure this variable, as unlike the multistage field test, it assesses a player's ability to recover from repeated high-intensity running efforts and thus demonstrates some sport specificity. In addition, this test is considered a valid (0.86) and reliable (0.98) assessment of this variable.[29] Furthermore, submaximal tests (e.g., the cooper run and 1.5 mile run) are not recommended, as in addition to them being continuous in nature, they require pacing skills which may affect results.

Acceleration, Speed and Speed-Endurance

Speed and acceleration are important qualities in field sports, with running speed over short distances fundamental to success.[4,8] Time motion analysis in rugby league suggests shorter distances (approximately 5–6 m) are sprinted by forwards than backs (fullback, wingers and centres), as they were observed to cover a greater distance in the lead up to a tackle (approximately 8–12 m).[28] Similarly, motion

Table 2. Skinfold sites and the associated error used for the determination of body fat percentage.[1]

Method	**Sites**	**% Error Male**	**% Error Female**
7 Site formula	Chest, Midaxillary, Triceps, Sub-scapular, Abdomen, Suprailiax, Thigh	3.5%	3.8%
3 Site formula	Chest, Abdomen, Thigh (men only) Triceps, Suprailiac, Thigh (women only)	3.5%	3.9%
3 Site formula	Chest, Triceps, Sub-scapular (men only) Triceps, Suprailiac, Abdominal (women only)	3.6%	3.9%

Table 3. Protocol and parameters for the triple 120m shuttle (T120S).[27]

Name of Test	Protocol	Maximum HR (bpm)	Blood Lactate (mmol/L)
T120S	• player sprints 10m • drops to chest • rolls on to back (ensuring shoulders are in contact with the ground) • repeats in the other direction • The player then runs back and forth to the start in a shuttle style, with the distance covered equating to 40m	Trial 1 – 187.8 Trial 2 - 190.3	Trial 1 – 12.8 Trial 2 - 13.2

analysis in rugby union revealed that backs perform a larger number of sprints (≥50) within a game, with an average duration of 3 seconds.[13,14] Cunniffe *et al.,*[12] and Meir *et al.,*[32] documented a sprint distance in both rugby codes (league and union) of 10-20m in one single bout, with back's covering a greater total sprinting distance than forwards (>20 km/h, 524m *vs.* 313 m). Additionally, backs and forwards in rugby league sprint approximately 2.3% and 1.9% of a game respectively. King, Jenkins and Gabbett[28] suggest that every 4 seconds of high-intensity exercise (e.g. tackle, sprint) is followed by approximately 21 seconds of low-intensity exercise, with an exercise-to-rest ratio of 1:5-1:6. It therefore, appears apparent that the ability to accelerate and reach high speeds is fundamental, along with the ability to recover from high intensity bouts.

Previous literature within rugby league has analysed sprint performance through a single linear sprint of 40m, with time intervals at 10m, 20m, and 40m being recorded.[22] This encompasses the acceleratory (10m) and top speed (20-40m) phases of running. However, in team sports, top speed is rarely attained, with acceleration proposed to last several metres for the sole purpose to engage in play.[11] Additionally, it is further suggested that engaging in a sprint from a standing position is rare within team sports, as players are frequently active prior to the initiation of a sprint.[33] Nonetheless, engaging in a sprint from a standing start cannot be disregarded, as in general play a defensive line will be stationary before commencing a sprint to the ball carrier in order to make a tackle. Furthermore, speed following a flying start can be assessed as the time taken between the 20 and 40m gates.

The ability to perform repeated sprints with minimal recovery between bouts is an important attribute for team sport players.[6] This is termed repeat sprint ability (RSA), which is often assessed over successive sprints with limited recovery between sprints.[8] The duration and pattern of sprints, along with the rest between them, can be modified to account for sport specific movement patterns and work-to-rest ratios. For example, the triple 120 metre shuttle (T120S) is a rugby league specific test which is characterised by sport specific movements (*Table 3*). The time taken to complete a repetition was between 43.14 - 49.46 seconds, which is similar to the time to completion of a defensive set where a player would be in constant motion. The maximum blood lactate identified in the two trials is similar to previous findings of 8.2mmol/L during an 80 minute rugby league match.[10]

In conclusion, the traditional method of linear sprinting with timing gates at 0m, 10m, 20m and 40m is beneficial in quantifying a player's acceleration (0-10m) and top speed from a stationary (0-40m) and rolling start (20-40m). While assessing linear sprint on a team can be undertaken with relative ease, an RSA test may require more time and several S&C coaches to record, oversee and administer the test. This may be impractical when fitness testing a large squad and therefore, despite the apparent relevance of RSA tests, is often omitted.

Agility

Rugby league players require a substantial amount of agility during a game and this parameter has been found to differentiate between rugby league players at national league and third division levels.[5,20] Sassi *et al.*,[37] applied the term agility to describe any dynamic sporting action that involves a change in body position or change of speed in a given direction. Although adequately defined, recent research suggests that a sport-specific stimulus should also be evident.[38] Nevertheless, it seems negligible to discount closed agility drills (i.e. Illinois agility run, t-test, hexagon agility), as these may be effective in facilitating a programme of multi-directional speed. Furthermore, incorporating a sport specific stimulus requires specialist equipment and additional resources (including more S&C coaches) and is thus often impractical.

To date, no specific rugby league agility test is universally advocated. However, previous literature within rugby league and team sports have frequently utilised tests such as the Illinois agility test,[18,20] L- run,[17] t-test[35,37] and pro-agility test.[24,30] However, not all of these tests replicate the biomechanical requirements. For example, the t-test and L-run profoundly rely on linear acceleration, speed and changes of direction (COD) in the frontal and sagittal plane only.

Conversely, the pro-agility and Illinois agility (*Table 4*) have aspects of all planar motion (frontal, sagittal and transverse), which is imperative within all facets of rugby league and team sports as a whole. A significant positive of the pro-agility is its ability to replicate game-play as the fast turning, twisting and sprint is not too dissimilar from a team's scramble defence in which quick sharp cutting movements are required to chase down the opposition. Tominaga *et al.*,[39] also suggested the pro-agility test was able to differentiate between playing positions of team sports athletes, thus further highlighting the tests validity.

Secondly, the Illinois agility test is a combination of linear acceleration and cutting movements. The constant motion of the Illinois agility is replicable to a defensive line in which a 10m deficit from the play-the-ball is upheld. However, limitations are apparent as the test requires the athlete to step/turn off their left foot, thus it may be prudent to change the start and finish

Table 4. Testing protocol for the pro-agility and Illinois agility tests.

Name of Test	
Pro-agility test (5-10-5)	The athlete starts in the middle of two 5m cones. Then on either an auditory stimulus or their own volition, the athlete would run to their left (5m), touching the cone with their right hand, following this a sprint to the far right cone (10m), touch with their left hand, then back to the start.[25]
Illinois Agility	The player starts on their chest and on command would rise and sprint 10m, turn and return to the starting line. After returning to the starting line, they would swerve in and out of four markers, and then back through them to the starting marker. Another 10m sprint would then be completed to the penultimate cone and then to the finish.[20]

point of the drill to eliminate unilateral bias. Furthermore, a possible modification of the Illinois agility test is to incorporate backwards running as this will aid in replicating a defensive line. Thus the first sprint which is 10m could then be followed by a 10m backwards run to the start which would further enhance the tests specificity. Of course, one must be sure that alterations to a test do not negatively impact on its reliability and thus invalidate it. Currently therefore, and due to ease of administration, we advise the pro-agility test.

Strength and Power

It is logical to assume that rugby league players require the ability to generate high muscular force rapidly, to perform effectively the tackling, pushing, jumping, pulling, sprinting, and changes of direction common to the game. Undoubtedly then, high levels of strength and power are essential determinants for successful participation in elite levels of rugby league[3,5] and it is therefore imperative for S&C coaches to effectively train and test this variable.

Strength and power are often quantified through 1RM testing such as the squat, bench press, and power clean, and more simplistically, through the squat jump (SJ - measure of lower body strength), and counter-movement jump (CMJ - measure of lower body power) tests. The 1RM squat is the most popular exercise for developing and assessing lower-body strength, with high correlations identified with other physiological attributes[41] such as 10m sprint (r=0.94, P=0.001), 30m sprint (r=0.71, P=0.01) and CMJ height (r=0.76, P=0.02). Often coupled with the squat in assessing muscular strength is the bench press and is one of the primary tests for evaluating upper-body muscular strength.[31] Meir *et al.*,[32] reported differences in 1RM squat (188 vs 168kg) and bench press (119 vs 113kg) strength in forwards and backs, highlighting positional differences.

For the majority of sports performance, power output is the critical mechanical quantity required rather than force production at low frequencies. The power clean is an accepted measure of identifying high-load power; however, this can only be administered once the athletes are technically competent. The CMJ is an example of a low-load power test and has the advantage of being relatively quick to administer. For accuracy however, it is recommended that jump tests are carried out on a switch mat which has high levels of test-retest reliability between the trials of the CMJ (r=0.98) and SJ (r=0.96).[9]

Reactive Strength

Reactive strength (RS), which describes an athlete's stretch-shortening cycle mechanics, is fundamental to an athlete's ability to quickly develop force (i.e., rate of force development), increase propulsion, change direction and conserve metabolic energy during locomotion.[40] As aforementioned, these are all skills inherent to successful rugby league players and thus it is prudent to suggest that a player's RS be quantified. A depth jump (DJ) is primarily utilised to record RS,

Table 5. Battery of field and gym tests, listed in order with suggested rest intervals

Test	Rest Intervals
Anthropometry (i.e. height, weight and 3-site BF% assessment)	N/A
Pro-agility (5-10-5)	3min intervals between reps (best of 3 trials)
Linear Speed (timing gates at 0, 10m, 20m,& 40m)	3min intervals between reps (best of 3 trials)
SJ	
CMJ	>30sec intervals between reps and tests
RSI (via DJ from 30cm box)	
1RM Power Clean	≥5min intervals between reps and tests
1RM Squat	
1RM Bench Press	
T120S (RSA)	T8min rest before moving onto the next
Yo-Yo Intermittent Recovery	N/A

Table 6. Repetition prediction based on 1RM. Adapted from Baechle et al.[2]

%1RM	Predicted Reps
100	1
95	2
93	3
90	4
87	5
85	6

with the RS index calculation derived from dividing the height jumped by the time in contact with the ground.[16] The DJ is usually conducted from various box heights, however, based on the opinions of the authors, it is rarely necessary to exceed 30cm boxes for purposes of testing.

Sequence of testing

The sequencing of tests can determine the success or failure of a battery[36] and thus, a high content validity and precise timing between tests and repetitions is imperative.[7] General guidelines to implementing a fitness testing battery include performing non-fatiguing tests first and testing highly skilled tasks (agility, explosive ability) before fatiguing tasks (endurance).[25] The National Strength and Conditioning Association (NSCA) suggested the following order: resting and non-fatiguing (heart rate, body composition, flexibility and jump tests), agility, power and strength, sprints, local muscular endurance, anaerobic capacity and aerobic capacity tests.[25] Using this data, along with the needs analysis and described tests herein, a suggested battery of fitness tests for rugby league players is proposed in *Table 5*.

Practical Application of a Theoretical Model

In reality, and despite the significant advances in sport science, whereby tests can be administered more quickly and the knowledge base has grown exponentially, time still remains very limited. Professional teams have a rather expansive multidisciplinary team, including physiotherapists, nutritionists, psychologists, fitness trainers and sports coaches and managers. Each have important roles and require a portion of the players time. Therefore, any fitness testing conducted, with the possible exception of pre-season, must be streamlined and strategically implemented if fitness is to be monitored regularly. For example, body fat and aerobic capacity tests often prove too time consuming for in-season testing, and significantly, the latter also increases fatigue and thus negatively impacts on training and general recovery. Similarly, RSA tests are too time consuming to be included at any stage of the season. Moreover, due to the high correlations (>0.8) often demonstrated between the SJ, CMJ and DJ (unpublished data of the second author), only CMJ need be taken with changes in this variable indicative of changes in the other two. Finally, it is far more efficient to calculate 1RM's based on training loads via percentage conversion tables (*Table 6*).

Conclusion

In summary of the needs analysis conducted herein, and based on experience of applying scientific concepts within practical settings, *Table 7* identifies a rugby league relevant (and realistic) fitness testing battery for pre- and in-season phases. The pre-season battery can help devise S&C programmes, while the in-season battery is aimed at monitoring progress.

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Table 7. Fitness Testing Battery based on the theory-application model.

Test	Pre-Season	In-Season
Anthropometry	Yes	No
Pro-agility	Yes	Yes
Linear Speed	Yes	Yes
SJ	Yes	No - Infer from CMJ data
CMJ	Yes	Yes
RSI	Yes	No - Infer from CMJ data
1RM Power Clean	Yes	No – use current training loads and 1RM conversion charts
1RM Squat	Yes	
1RM Bench Press	Yes	
T120S (RSA)	No	No
Yo-Yo Intermittent Recovery	Yes	No

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