QUANTIFYING THE EXTERNAL AND INTERNAL LOADS OF PROFESSIONAL RUGBY LEAGUE TRAINING MODES: CONSIDERATION FOR CONCURRENT FIELD-BASED TRAINING PRESCRIPTION

INTRODUCTION

The intermittent movement, collision and skill components of professional rugby league match play require players to have a wide range of physical (e.g. repeated effort ability, speed) and technical qualities (e.g. passing, kicking, tackling ability) to attain successful competitive performance.[1] To induce varied adaptations, practitioners manipulate the fundamental training principles (e.g. intensity, duration and type) to concurrently prescribe multiple modes such as small-sided games (SSG), technical-tactical and sprint training.[2-4] For large proportions of the calendar year, this prescription must also be considered within an individual's time-course of recovery following the load imposed by competition.[2] As a result, ensuring the appropriate concurrent prescription of multiple modes of training poses a complex challenge for practitioners due to the need to balance an appropriate variance in training load that maximises training induced adaptations in a wide range of physical and technical qualities whilst also minimising negative outcomes (e.g. injury incidence).[5]

Understanding the organisation of the prescribed *external* load (i.e. the intensity and duration of distance, speed, and acceleration activities) and the resulting psycho-physiological and biomechanical responses that comprise the *internal load* are key considerations within the overall training process.[6] Currently, there are numerous methods used to quantify the two constructs, including heart-rate (HR; internal)[7,8], perceptual (session rating of perceived exertion [sRPE]; internal)[3] and micro-technology including global positioning systems (GPS; external), and tri-axial accelerometers (external).[4] Primarily, these are used to determine the accumulated load from a session which is typically averaged across both chronic (e.g. 28-days) and acute (e.g. 7-days) training periods to manage global training load prescription.[6] To assist this, load data can also be used to plan the contribution of each mode to this global accumulated load by determining the likely external and internal load per minute of training time. This can be achieved by dividing the total session load for a given method by the session duration. Understanding how the relative, rather than absolute, load differs across modes and to what magnitude, could allow practitioners to 'allocate' future absolute loads by multiplying the relative load by the planned session duration.

For certain training modes such as SSG, the specificity of the external load to competition is an important focus[2] although the understanding of the external loads of rugby league training[2] is limited in comparison to competition.[1,9-13] The most commonly reported method to represent the external load is the absolute and relative (to time) total distance.[2,12-13] Given the intermittent nature of rugby league, total distance is also frequently categorised into arbitrary speed zones to describe the intensity distribution of the locomotor activities performed.[2] However, whilst there is much debate over the use of arbitrary *vs* individualised thresholds for such purposes,[14-15] an additional consideration is that representing the external load solely via speed-derived methods could underestimate the contribution of changes of direction and the resulting acceleration and deceleration events, particularly maximal accelerations that can occur despite low-speeds.[17,18] This is particularly important due to the nature of rugby league, as spatial constraints (i.e. 10-metre rule) are prevalent during competition and within prescribed training drills[16] which is likely to increase the frequency of changes in direction, acceleration and deceleration events. As a result, the metabolic power approach has been proposed as a method which incorporates the cost of accelerated running[17] and has subsequently been implemented to estimate the external load of soccer training[19] and rugby league match play.[9] Using comparable thresholds[17] of high metabolic-power (> 20 $W \cdot kg^{-1}$) and high-speed (> 14 $km \cdot h^{-1}$) distances during professional rugby league competition, Kempton *et al.*[9] reported high-metabolic-power to estimate greater distances compared to high-speed across all playing positions, particularly in the hit-up forwards (76% increase). The activities of hit-up forwards are predominant in the middle of the field during competition to progress (in attack) or limit (in defence) field-position. Therefore, hit-up forwards could spend a greater proportion of time accelerating maximally yet failing to reach a high-speed threshold. This suggests that the distances determined from metabolic power could also provide additional insight into the between-mode differences in external load of professional rugby league training, particularly those that involve spatial constraints. However, research detailing both the speed- and metabolic-power-derived distances across training modes in professional rugby league has yet to be investigated.

Whilst details of the external training load is important to understand the overall training process, the internal load governs the training induced adaptations required to succeed in competition.[6] Despite the importance of the internal load to the outcomes of training[6-8] there is limited information reporting how the internal load differs across common training modes utilised in rugby league. The heart-rate based individualised training impulse (iTRIMP) has previously been used to quantify the internal loads of professional and youth soccer training and has demonstrated moderate to large associations with team sport specific changes in physical performance, including the Yo-Yo Intermittent Recovery Test 1 (r = 0.69, p = 0.01) in elite soccer players[8] and with physiological changes such as the velocity at lactate threshold (r = 0.67; p = 0.04) in professional youth soccer players.[7,] Alternatively, sRPE is a simple, inexpensive and widely adopted perceptual based method to quantify the internal load.[3] However, the limited information detailing the mode-specific training loads in professional rugby league training has reported only absolute external loads[2] or perceptual (sRPE) internal training loads.[3] Therefore, the aim of the current study was to establish the magnitude of difference of time-relative external and internal training load methods across the modes of training (conditioning, SSG, skills and sprint) that are used to prepare professional rugby league players for the demands of competition. A secondary aim was to compare the distances derived from metabolic-power and speed-derived external load methods within-modes of training.

Methods

Experimental Approach to the Problem

A longitudinal observational research design was used in which external (GPS) and internal (heart rate and sRPE) training data were collected during two 12-week pre-season periods across two European Super League seasons. Throughout the data collection period, the club coaching staff prescribed the training programme and players typically completed 5-8 training sessions per week which were all conducted outside at the clubs training facility on a grass surface. Typically, skills and conditioning were prescribed twice a week with speed and SSG prescribed weekly, although this varied throughout the two separate pre-season periods. A total of 716 individual training sessions were collected during the study with players providing 42 ± 13 sessions each (SSG: n = 111; skills: n = 287; conditioning: n = 194; speed: n = 124). Training sessions that included 'hybrid' activities (e.g.

players completed bouts of small-sided-games then completed bouts of sprint- or skills-training within a single session) were not included in the dataset. Data were ‘clipped’ in real-time during each session (TeamAMS Version 2014.3, GPSports, Canberra, Australia) so that drinks breaks were omitted from the session durations although prescribed rest periods (i.e. during interval based training during conditioning) were included. The lead researcher, in collaboration with club coaching staff, defined the training modes prescribed but was not involved in the prescription of any content relating to each training mode. Given the longitudinal nature (i.e. 2 consecutive pre-season periods) and the standard of players within the study design, the content of each training mode (e.g. intensity, frequency and duration of exercise bouts, number of players, pitch dimensions and technical-tactical content) could not be standardised throughout the data collection period. An overview of content included within each mode is summarised below:

1. SSG: Small sided, high intensity ‘off-side’ and ‘on-side’ conditioning games which aimed to concurrently improve rugby league specific fitness and execution of skills under fatigue. Players typically competed in teams of 6 on either a 10-m width x 40-m length or 40-m width x 70-m length playing area.

2. Conditioning (CON): linear- and shuttle-running which aimed to improve players capabilities to tolerate repeated high-intensity running bouts. The distances for these running drills were prescribed for each player based on a percentage of the maximal aerobic speed generated from a 4-minute running time trial for maximal distance. This ranged from 4-minutes continuous based running with 3-minutes passive recovery to 30s shuttle running with 30s passive recovery both at a percentage of their maximal aerobic speed.

3. Skills: Individual-, positional- and team-based drills which focused on enhancing individual rugby league skills and team technical-tactical strategies. This was the only mode to have contact episodes prescribed during a proportion of the sessions.

4. Sprint training: drills which aimed to improve sprint kinematics (technique drills), acceleration (e.g. maximal running over 10 and 20 metres) and maximal velocity running (e.g. 40 to 60-m sprints).

Subjects

Seventeen male professional rugby league players (9 forwards and 8 backs) from one European Super League club (age: 25 ± 3 yrs.; height: 186.0 ± 7.7 cm; mass: 96.0 ± 9.3 kg; playing experience either European Super League or National Rugby League: 106 ± 93 matches) participated in this study. The study was granted ethics approval by the Department of Sport, Health and Exercise Science Human Research Ethics Committee in accordance with the Declaration of Helsinki. Written informed consent was obtained from each player prior to the start of the study.

Procedures

During all training modes, players wore a microtechnology device including both a 5 Hz with 15 Hz interpolated GPS (SPI Pro XII, GPSports, Canberra, Australia) and 100-Hz tri-axial accelerometer. The SPI Pro XII (GPSports, Canberra, Australia) device has demonstrated an acceptable level of accuracy and reliability for measures of total distance and peak speed during a team sport specific circuit.[20] Each player wore the same GPS device throughout the data collection period to limit potential inter-unit variability.[21] Throughout the data collection period, the mean (SD) number of satellites and horizontal dilution of precision was 9 (1) and 0.94 (0.30) respectively.[22] Training data were categorised into the distance (m) covered at various movement speed bands which corresponded to walking (0 to 1.94 $m \cdot s^{-1}$), jogging (1.95 to 3.87 $m \cdot s^{-1}$), striding (3.88 to 5.4 $m \cdot s^{-1}$) and sprinting (≥ 5.5 $m \cdot s^{-1}$). High-speed running was determined by summating the distances covered at striding and sprinting speeds (i.e. ≥ 3.88 $m.s^{-1}$).

Calculations for the distance covered at low- (0 to 9.9 $W \cdot kg^{-1}$), intermediate- (10 to 19.9 $W \cdot kg^{-1}$), high- (20 to 34.9 $W \cdot kg^{-1}$), elevated- (35 to 54.9 $W \cdot kg^{-1}$), and max-power (≥ 55 $W \cdot kg^{-1}$) thresholds were calculated using the instantaneous energy cost equations provided by di Prampero and colleagues.[23] as used in previous studies.[9,17,19] The equivalent distance (EQ distance), which represents the steady state distance required to match the estimated energy expenditure inclusive of accelerative running was also calculated as per previous studies.[9,17,19] High-metabolic-power-distance was determined by summating the distances covered at high-, elevated- and max-power thresholds (i.e. ≥

20 W·kg^{-1}). Metabolic power data were calculated within the proprietary software (TeamAMS Version 2014.3, GPSports, Canberra, Australia) and exported to a custom made spreadsheet for data management.

Internal training load involved calculating the sRPE for each player during the study period using the method of Foster et al. (2001).[24] Exercise intensity for sRPE was determined using Borg's CR-10 scale[25] which was collected ~30 minutes following the completion of the training session. RPE was then multiplied by the training session duration to calculate the sRPE training load in arbitrary units (AU).[3,4] All players who participated in the study had been familiarised with the RPE scale including the interpretation of exertion in relation to the verbal anchors placed within the scale. To eliminate third-party observation during collection, players were required to provide the lead researcher with their sRPE in a room with only the lead researcher present which was inputted into a custom made spreadsheet.

The iTRIMP is a heart-rate based method to quantify the internal training load, and has shown dose-response validity with changes in fitness in team sports athletes.[7,8] In order to calculate the iTRIMP measure, players undertook an incremental stage test on a motorised treadmill (Woodway ELG55, Woodway, Weil an Rhein, Germany) and a resting HR test. This was conducted during the first week of each pre-season period immediately prior to the commencement of the formal pre-season training period. Players avoided any strenuous exercise in the 24 hours preceding the tests. Resting HR (HR_{rest}) was recorded (Polar F3, Polar Electro, OY, Finland) from the subjects in a resting state prior to the first test. The resting state involved lying in a supine position in a quiet room. HR_{rest} was taken as the lowest 5s value during the 5 minute monitoring period. Players then completed an incremental treadmill test to assess the participants blood lactate-heart rate relationship during incremental exercise.[7,8] This consisted of five, 4 minute sub-maximal stages commencing at an initial running velocity of 7 km·h^{-1} with 1 minute recovery given between stages. A finger capillary blood lactate sample was collected during the 1 minute recovery period during the sub maximal stages and immediately analysed in duplicate (YSI 2300, YSI inc, Yellow Springs, OH). Treadmill velocity was increased at every stage by 2 km·h^{-1} until a maximal speed of 15 km·h^{-1} was reached. Following this, a ramp protocol was used to determine an individual's maximal HR (HR_{max}). The ramp protocol commenced at an initial velocity of 15 $km \cdot h^{-1}$ and increased at increments of 1 $km \cdot h^{-1}$ per minute until volitional fatigue. HR data were collected throughout the treadmill test (every 5s) using Polar HR straps (T14, Polar, Oy, Finland). The highest HR recorded at the completion of the ramp protocol was used in order to determine the individual's HR_{max}.

The HR_{max} measured during the maximal incremental test was used as the reference value for iTRIMP calculation. The iTRIMP was calculated for each player for each training session for the duration of the study using previously described methods.[26] Briefly, the iTRIMP is described in formula 1:

$$(1)\ \text{Duration} \times \Delta HR \times ae^{bx}$$

Where ΔHR equals $HR_{exercise} - HR_{rest}/HR_{max}\text{-}HR_{rest}$, a and b are constants for a given player derived from the regression equation calculated from the relationship between blood-lactate and fractional elevation of HR during the incremental treadmill test[26], e equals the base of the Napierian logarithms and x equal's ΔHR.[7] Each player's equation was generated from their own data collected from the incremental treadmill test. Heart rate was collected during each training session (every 5s) using Polar HR straps (T14, Polar, Oy, Finland) which transmitted continuously to the GPS monitor (SPI Pro XII, GPSports, Canberra, Australia). To determine the iTRIMP value for each session, each 5s heart rate during the session is weighted according to formula 1 and then summed. Raw HR data for every training session were exported from the GPS manufacturer software (TeamAMS Version 16.1, GPSports, Canberra, Australia) into dedicated software to determine individual session iTRIMP values (iTRIMP Software, Training Impulse LTD, UK).

Statistical Analyses

To account for differences in training duration between training modes, all data were divided by session duration with all data expressed per minute. Data were log transformed to reduce the bias that results due to non-uniformity error. Magnitude based inferences were used to determine the practical meaningfulness of the differences in relative external and internal load across training modes (conditioning, SSG, skills and sprint training).[27] The standardised mean difference (SMD) was used to determine the magnitude of differences in the dependent variables ± 90% confidence intervals (CI).[27] Standardised mean differences of <0.20, 0.20-0.60, 0.61-1.19, 1.20-2.00 and >2.00 were considered trivial, small, moderate, large, and very large respectively.[27] The threshold difference which was considered to be practically important (smallest worthwhile difference; SWD) was set at 0.2 x between-subject standard deviation (SD). Based on 90% CI, the thresholds used to assign qualitative terms to chances were as follows: <0.5%, *most unlikely*; 0.5-5%, *very unlikely*; 5-25%, *unlikely*; 25-75%, *possibly*; 75-95% *likely*; 95-99.5%, *very likely*; >99.5%, *almost certainly*. The magnitude of difference was considered practically meaningful when the likelihood was ≥75%. Where the 90% CI crossed both the upper and lower boundaries of the SWD (ES ± 0.2), the effect was described as *unclear*.[27]

RESULTS

Table 1 displays the mean ± SD of the relative external (both speed- and metabolic-power) and internal (iTRIMP and sRPE) training loads for each training mode (CON, SSG, skills and sprint training).

*** INSERT TABLE 1 HERE***

Relative velocity-distances

Figure 1 shows the magnitude (standardised mean difference [90% CI]) and likelihood of difference in relative ($m \cdot min^{-1}$) speed-derived-distances (total; walk; jog; stride and sprint) between training modes (CON *vs* SSG; CON *vs* skills; CON *vs* sprint training; SSG *vs* skills; SSG *vs* sprint training; skills *vs* sprint training).

*** INSERT FIGURE 1 HERE***

Relative metabolic-power-distances

Figure 2 shows the magnitude (standardised mean difference [90% CI]) and likelihood of difference in relative (m·min^{-1}) metabolic-power-derived-distances (equivalent; low-; intermediate-; high-, elevated-, and maximal-power) between training modes (CON *vs* SSG; CON *vs* skills; CON *vs* sprint training; SSG *vs* skills; SSG *vs* sprint training; skills *vs* sprint training).

Internal load

iTRIMP, was *almost certainly* greater during CON than skills (SMD [90% CI]; descriptor: 2.37 [1.76 to 2.99]; very large) and speed (SMD = 2.91 [2.19 to 3.64]; very large) training whilst this was *unclear* (SMD [90% CI] = 0.02 [-0.45 to 0.49]; trivial) between CON and SSG. iTRIMP was *almost certainly* greater during SSG than skills (SMD = 2.35 [1.75 to 2.95]; very large) and sprint training (ES = 2.89 [2.26 to 3.53]; very large). The difference in iTRIMP between skills and sprint training was *unclear* (SMD = 0.54 [-0.24 to 1.32]; small).

sRPE was *likely* greater during CON *vs* SSG (SMD = 0.61 [0.15 to 1.06]; moderate) and *almost certainly* greater during CON *vs* skills (SMD = 6.49 [5.44 to 7.54]; very large) and sprint training (ES = 8.21 [7.27 to 9.14]; very large). sRPE was *almost certainly* greater during SSG *vs* skills (SMD = 5.89 [4.90 to 6.87]; very large) and sprint training (SMD = 7.60 [6.53 to 8.67]; very large). sRPE was *very likely* greater during skills *vs* sprint training (SMD = 1.71 [0.24 to 3.19]; large).

High-Speed Distance vs High-Metabolic-Power Distance

The difference in high-speed-distance and high-metabolic-power-distance was *possibly* trivial for CON (SMD [90% CI] = 0.19 [-0.19 to 0.56]; trivial) and *likely* trivial for sprint training (SMD = 0.04 [-0.15 to 0.23]). High-metabolic-power-distance was *almost certainly* greater than high-speed-distance during SSG (SMD = 0.75 [0.48 to 1.02]; moderate) and skills (SMD = 1.36 [0.99 to 1.72]; large).

DISCUSSION

The aim of the current study was to establish how numerous external and internal training load variables differed per minute across the different modes of training (conditioning, SSG, skills and sprint training) that are used to prepare professional rugby league players for the demands of competition. A secondary aim was to investigate the within-mode differences in 'high-intensity' distance as quantified at greater than 3.88 $m \cdot s^{-1}$ (high-velocity) or 20 $W \cdot kg^{-1}$ (high-metabolic-power). The findings show substantial differences in the composition of the external load per minute across training modes (SSG, CON, skills and sprint training). This highlights the varied field-based running demands placed onto professional rugby league players as part of the overall training process.

External Training Load

Comparing CON to SSG, players cover greater distances per minute moving at moderate velocities (1.95 to 5.49 $m \cdot s^{-1}$) and metabolic-power (10 to 34.9 $W \cdot kg^{-1}$) during CON (Figure 1 & 2). Within SSG, players were found to cover greater distances at high-metabolic-power ($\geq$ 20 $W \cdot kg^{-1}$) than high-speed ($\geq$ 5.5 $m \cdot s^{-1}$) whilst *trivial* differences existed between the variables during CON. This demonstrates that players complete a greater proportion of 'high-intensity' activity while accelerating and decelerating during SSG and maintain greater proportions of high-speed running during CON. Compared to skills training (technical-tactical development) and sprint training (maximal speed development), SSG and CON possess similar central aims (e.g. prolonged high-intensity running ability development) and practitioners should consider their differences in the organisation of the external load when planning training prescription. For example, more acceleration and deceleration activity lead to greater force production at the hip, knee and ankle joints[28] and subsequently greater structural damage to skeletal muscle tissue.[29] During in-season training therefore, practitioners could use data such as this to plan drills which provide the greatest acceleration/deceleration demands earlier in the training week to allow appropriate recovery prior to competition.[29]

The whole-game relative mean (SD) total distance of European Super League competition has been found to range from 83 (2) to 104 (27) $m \cdot min^{-1}$ whilst high-speed distance has ranged from 12 (7) to 16 (3) $m \cdot min^{-1}$.[10,12-13] Therefore, whilst not considering positional differences, it appears that both CON and SSG can expose players to similar relative total and greater high-speed distances than ESL competition.[10,12-13] The mean high-metabolic-power distances found during SSG and CON also compare to those found in NRL match play (22 to 24 m·min^{-1}).[9] Although the current study did not directly compare to the match demands experienced by this group of players, the comparisons[10,12-13] provide suggestion that SSG and CON can appropriately prepare players for the mean speed- and metabolic-power derived running demands of competition. However, practitioners must also keep in mind that exposing players to the mean demands may increase the likelihood that players will be under-prepared for the most demanding passages of competition.[1] For example, Delaney et al.[11] reported the peak 10 minute average m·min^{-1} of National Rugby League competition to range from 98 to 109 m·min^{-1} between positions, suggesting the mean relative distances covered by ESL players during all training modes in the current study would leave players underprepared for this demand during competition. Therefore, to confirm this comparison, future research is needed to determine whether these modes of training prepare players for the peak demands of professional rugby league competition.[11]

For skills training, lower distances were observed across all arbitrary speed-derived variables compared to CON and SSG (SMD = large to very large). Although the session aims of CON and SSG focus predominately on the development of prolonged high-intensity running ability[2], skills training aims to enhance passing, catching, tackling technique and defensive line shape within drills that consist of variable constraints (e.g. 10-m rule, changes in player numbers).[30] The presence of physical contact has been reported to reduce locomotor output during rugby league activities.[31-32] Therefore, as contact episodes were only prescribed during skills training in the current study, this could explain some of the reduced running outputs found during skills compared to SSG and CON. However, the magnitude of difference in the distances covered within a number arbitrary metabolic-power thresholds (SMD = small to large) was reduced in skills *vs* SSG and CON in comparison to speed-derived methods. This suggests that the magnitude of difference between the three modes is reduced when taking into account accelerative activity. This is also supported by the *almost certainly* greater distances covered during skills derived from high-metabolic-power compared to that at high-speed. This is likely due to the spatial confinements that result from the limited space between attacking and defensive lines which increase the proportion of high-magnitude acceleration activity during skills training.[9,11] In contrast, the session aims of CON focuses on greater periods of continuous bouts of training and thus a proportionally reduced contribution from accelerative activity. This appears to be reflected in the differences between the distances above either high-speed or high-power thresholds in the current study. Given skills training is the most frequently prescribed training mode across the season, the appropriate quantification of the external load during skills training is particularly important.[3-4] This suggests that the magnitude of the external load could be underestimated if acceleration is not quantified during skills training. Therefore, practitioners should consider that adopting only speed-derived methods could underestimate the total external load of this mode of training.

Internal Training Load

The findings showed that players *likely* perceived (sRPE) a greater internal load during CON than SSG. A greater mean sRPE during conditioning (8.8 ± 1.1) compared to SSG (7.2 ± 1.5) has also been reported in professional NRL players.[3] Whilst speculative, the *unclear* differences in iTRIMP and numerous external load metrics between SSG and CON suggest that factors that do not concurrently increase the external load (e.g. ball involvement) contribute to the differences in perceptual response between the two training modes. However, numerous factors, such as the number of players, pitch size and rule constraints have also been reported to influence the perceptual response between SSGs.[32-36] Therefore, as both current and previous[3] studies adopted longitudinal (e.g. > 1 year) observational research designs, coaches are likely to have manipulated these factors during this time. This variability in SSG prescription is likely to limit the inferences of the mechanisms behind the greater perception of effort during CON compared to SSG reported in the current study. Due to the *unclear* findings, further research (which should attempt to control the external load between SSG and CON conditions) is required to establish the mechanisms behind the increase in effort perception found during CON compared to SSG training in both current and previous studies.[3] Despite this, both CON and SSG exposed players to *almost certainly* greater internal loads (sRPE and iTRIMP) compared to both skills and sprint training. During sprint training, players were also found to cover greater sprint distances yet lower relative distances across all other speed- and metabolic-power thresholds compared to CON and SSG. Collectively, the findings suggest that CON and SSG provide the greater overall accumulation of load per minute of training whilst sprint training provide players with the greatest proportion of high-speed running without a concomitant increase in internal load. For rugby league players, this provides support for the supplementation of sprint training within the overall training plan to expose players to this intensity of running when required without proportionally increasing the overall total distance covered compared to other modes of training.

Despite the current findings, the study is not without limitation. Firstly, although the inclusion of acceleration into the determination of the external load provides useful information to aid our understanding of rugby league training, it is important to evaluate the limitations of the metabolic-power method and the energetics approach by di Prampero et al. (2005).[23] More specifically, the model assumes that the total mass of a player is located at the centre of mass which neglects the effect of limb motion on running.[13] In addition, the model fails to account for the influence of air resistance or the energetic cost of eccentric work which could under represent deceleration events.[9,18] Secondly, whilst the findings demonstrate the differences in internal and external load per minute of training between common training modes, it must be acknowledged that the data were collected from only one ESL club which didn't consider positional differences between modes and with data collected during the pre-season phase. As a result, the magnitude of difference between the modes may be influenced by the group of players and particularly, coaching methods within each training mode which might not be representative of all rugby league clubs. It is also possible that the specific relative loads found in the current study could change during in-season training, where recovery and preparation for competition become primary aims. In addition, whilst the study compared the 'global' differences in external and internal training load between modes, given the longitudinal nature of the data collection, these modes will comprise of multiple different drills, which are likely to comprise of varying magnitudes of internal and external load per minute of training time and increased variability in the duration of rest periods which likely confound the mean values reported in the current study. Further research is required to determine the relative internal and external loads of specific within-mode drills used to prepare professional rugby league players for the demands of competition. However, the study provides a process for how this data can be used in practice to establish normative external and internal loads per minute of training time (by dividing absolute session load by session duration) for different modes of training. This can be useful to evaluate the differences in the external and internal loads of different components of a field-based training programme. Once normative values are established for players, the external and internal load variables can then be used to plan future training periods by multiplying the normative load for a given variable by the planned session duration.

CONCLUSIONS

The present study has provided comparisons of the mean relative external and internal loads across modes of training (SSG, CON, skills, sprint training) in professional rugby league. The findings of the study have shown that different modes of training elicit differences in external and internal training load per minute of training time. For practitioners, this highlights how dividing the overall session loads per minute of training can be used to establish the differences in time-relative load for frequently prescribed training modes. This information can be extremely beneficial for coaches to plan (by multiplying the typical load per minute by planned session duration) multiple concurrent modes within the loading requirements for players across their short- and long-term training programmes. The findings also highlight the benefits of using metabolic-power variables to complement speed-derived methods for the practical implication of understanding the organisation of the external training load both within- and between-training-modes. Practitioners should therefore consider this within their evaluation of the relative field-based running demands to individualise the prescription of the running-based stimulus of the training programme. For example, based on the findings in the current study, if the training day was identified to include a requirement for high-intensity activity at high-speed which was not provided by the drills included during skills training, practitioners might consider the prescription of CON, rather than SSG, to provide players with greater proportion of exposure to high-speed rather than high-acceleration running.

PRACTICAL APPLICATIONS

- Practitioners should consider that whilst the overall external training load (e.g. total or equivalent distance per minute) can be similar between training modes, the composition of this overall load can vary across types of training.
- Sprint training exposes players to the greatest sprinting and maximal power running demands without an associated increase in internal load.
- Metabolic power measures of the external load compliment speed-derived methods, particularly during skills and SSG training which involve randomised activity within spatial constraints.
- Practitioners can establish normative information by calculating the relative training load for each training mode and individual, which can be used to plan future training loads by multiplying the relative load by the planned session duration.

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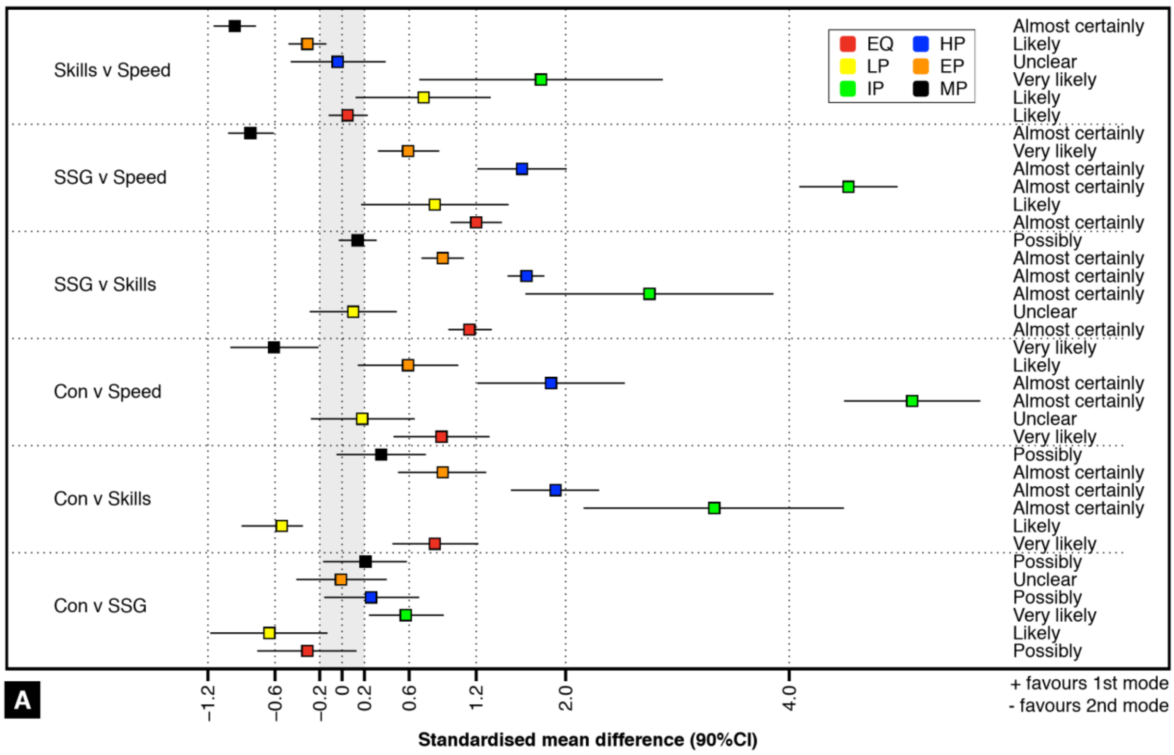
Fig 1. The difference (standardised mean difference [90% CI]) in the metabolic-power- (A) and speed-derived (B) threshold distances per minute of training time for each training mode comparison. The direction of the standardised mean difference is in relation to the first named training mode within each comparison. Grey area represents *trivial* differences.

Abbreviations: **A**: EQ = equivalent distance; LP = low power (0 to 9.9 $W \cdot kg^{-1}$); IP = intermediate power (10 to 19.9 $W \cdot kg^{-1}$); HP = high power (20 to 34.9 $W \cdot kg^{-1}$); EP = elevated power (35 to 54.9 $W \cdot kg^{-1}$); MP = maximal power (≥ 55 $W \cdot kg^{-1}$). **B**: TD = total distance; CON = conditioning; SSG = small-sided games; walk (0 to 1.94 $m \cdot s^{-1}$), jog (1.95 to 3.87 $m \cdot s^{-1}$), stride (3.88 to 5.4 $m \cdot s^{-1}$) and sprint (≥ 5.5 $m \cdot s^{-1}$).

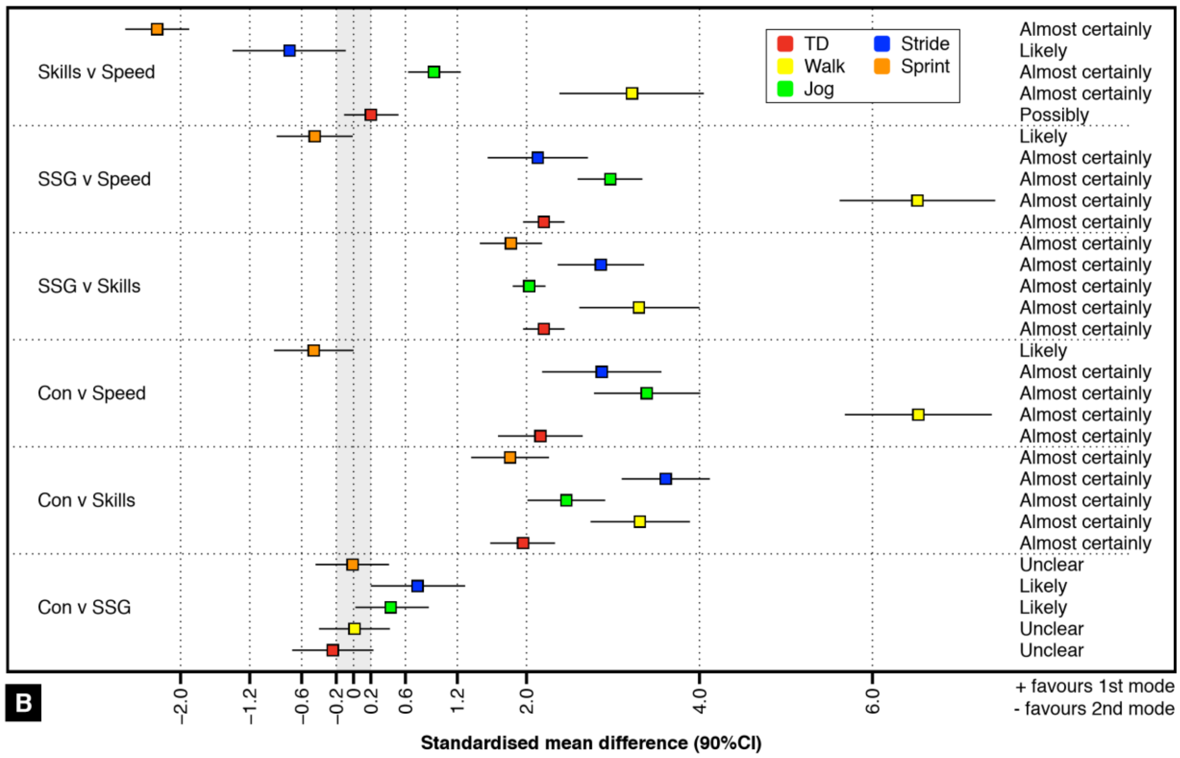
Table 1. Mean ± standard deviation for each relative external and internal training load measure during conditioning, SSG, skills and speed training.

Training Load Measure	Conditioning	SSG	Skills	Speed
Mode Duration (min)	52 ± 22	37 ± 14	40 ± 24	28 ± 8
Velocity-distance				
Total ($m{\cdot}min^{-1}$)	82 ± 12	85 ± 8	57 ± 2	55 ± 8
Walking ($m{\cdot}min^{-1}$)	26 ± 4	26 ± 4	15 ± 3	9 ± 2
Jogging ($m{\cdot}min^{-1}$)	11 ± 7	8 ± 1	3 ± 1	2 ± 1
Striding ($m{\cdot}min^{-1}$)	16 ± 7	12 ± 3	4 ± 1	6 ± 4
Sprint ($m{\cdot}min^{-1}$)	8 ± 9	6 ± 3	2 ± 1	9 ± 5
High-speed-distance ($m{\cdot}min^{-1}$)	24 ± 15	18 ± 6	6 ± 2	15 ± 8
Metabolic-Power-Distance				
Equivalent Distance ($m.min^{-1}$)	93 ± 19	100 ± 11	71 ± 4	70 ± 8
Low Power ($m{\cdot}min^{-1}$)	32 ± 4	35 ± 4	34 ± 5	31 ± 6
Intermediate Power ($m{\cdot}min^{-1}$)	25 ± 5	22 ± 3	15 ± 16	8 ± 2
High Power ($m{\cdot}min^{-1}$)	18 ± 7	17 ± 3	6 ± 1	7 ± 5
Elevated Power ($m{\cdot}min^{-1}$)	7 ± 8	5 ± 1	3 ± 0.5	4 ± 1
Maximal Power ($m{\cdot}min^{-1}$)	2 ± 1	2 ± 1	2 ± 0	4 ± 1
High-metabolic-distance ($m{\cdot}min^{-}$	24 ± 7	24 ± 4	10 ± 1	15 ± 7
Internal Load				
iTRIMP ($AU{\cdot}min^{-1}$)	2 ± 1	2 ± 0.4	1 ± 0.5	1 ± 0.4
sRPE ($AU{\cdot}min^{-1}$)	8 ± 0.5	7 ± 0.4	5 ± 0.7	4 ± 0.6

Abbreviations: *SSG*: small-sided games; iTRIMP: individualised training impulse; sRPE: session rating of perceived exertion.



Skills v Speed
SSG v Speed
SSG v Skills
Con v Speed
Con v Skills
Con v SSG
EQ
LP
IP
HP
EP
MP
Almost certainly
Likely
Unclear
Very likely
Likely
Likely
Almost certainly
Very likely
Almost certainly
Almost certainly
Likely
Almost certainly
Possibly
Almost certainly
Almost certainly
Almost certainly
Unclear
Almost certainly
Very likely
Likely
Almost certainly
Almost certainly
Unclear
Very likely
Possibly
Almost certainly
Almost certainly
Almost certainly
Likely
Very likely
Possibly
Unclear
Possibly
Very likely
Likely
Possibly
-1.2
-0.6
-0.2
0
0.2
0.6
1.2
2.0
4.0
+ favours 1st mode
- favours 2nd mode
A
Standardised mean difference (90%CI)



Skills v Speed
SSG v Speed
SSG v Skills
Con v Speed
Con v Skills
Con v SSG
TD
Walk
Jog
Stride
Sprint
Almost certainly
Likely
Almost certainly
Almost certainly
Possibly
Likely
Almost certainly
Almost certainly
Almost certainly
Almost certainly
Almost certainly
Almost certainly
Almost certainly
Almost certainly
Almost certainly
Likely
Almost certainly
Almost certainly
Almost certainly
Almost certainly
Almost certainly
Almost certainly
Almost certainly
Almost certainly
Almost certainly
Unclear
Likely
Likely
Unclear
Unclear
-2.0
-1.2
-0.6
-0.2
0
0.2
0.6
1.2
2.0
4.0
6.0
+ favours 1st mode
- favours 2nd mode
B
Standardised mean difference (90%CI)