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Factors affecting exercise intensity in professional rugby league match-play

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ABSTRACT

Objectives: To examine the effects of match-related and individual player characteristics on running performance in professional rugby league matches.
Design: Longitudinal observational study.
Methods: Global positioning system (GPS) and technical performance measures (attacking involvements and tackles made) were collected from 23 players competing in the National Rugby League (NRL) over 24 matches during a season. The GPS data were categorised into relative total distance ($m\ min^{-1}$) and relative high-speed running distance (HSR $m\ min^{-1}$, >14.4 $km\ h^{-1}$). Each match was classified according to season phase, location, recovery length, opposition strength and result. Individual player fitness status was obtained from a 1.2-km shuttle run test conducted prior to the start of the season. Two separate linear mixed models were constructed to examine the influence of match-related and individual player characteristics on relative total and HSR distances.
Results: Matches played away from home, early in the season and following short recovery cycles were associated with reduced relative total and HSR distances. Matches won contained less relative total and HSR distance; whereas only HSR distance was higher against weaker opposition. The total time the ball was out of play reduced relative total but not HSR distances. The number of defensive but not attacking involvements influenced both physical performance measures. Finally, player fitness was positively related to both relative total and HSR distances.
Conclusions: There appears to be a complex interplay of factors affecting match-running performance in rugby league. The results underline the importance of considering contextual factors when analysing rugby league match-activity profiles.

1. Introduction

Time motion analyses of competition matches – using either global positioning satellite (GPS) or video tracking technology – are now common for assessing time–motion profiles in rugby league[1,2] and other professional team sports.[3,4] Recent research has demonstrated that physical performance variables (particularly higher-speed activities) vary between individuals and throughout the course of the season.[5,6] Indeed, given the complex nature of team sport match-play, it is likely that a variety of situational factors including opposition strength, match outcome and competition scheduling contribute to the variation in physical activity profiles.[7,8] Additionally, individual player characteristics such as playing position and fitness characteristics may also influence physical performance profiles.[2,9]

Recently, several studies examined the influence of these match-related factors and individual specific qualities on physical activity profiles during rugby league match-play.[7–9] While these studies have expanded current knowledge of rugby league match-play, they are often limited in that they only examined these variables in isolation and have not adequately controlled for the confounding effects of multiple match-related factors on physical activity profiles. Additional research is therefore required to better understand the independent effects of these situational variables on physical activity profiles. Multilevel mixed modelling represents a method to examine the independent effects of a variable on an outcome variable whilst accounting for all other variables. Additionally, this technique allows for the analysis of clustered dependent data as is commonly collected in observational match-analysis studies. Therefore, the purpose of this study was to use a mixed models approach to examine the independent effects of

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Table 1
Covariates included in model specification.

Level of Data		Factors	Type	Classification
Level 3	Cluster of clusters (random factor)	*Position*		
Level 2	Cluster of units (random factor)	*Player*		
	Covariate	Fitness score	Continuous*	Maximal running speed ($m\,s^{1}$)
Level 1	Unit of analysis	*Individual match sample*		
	Dependent variable	Relative total distance (Model 1)	Continuous	$m\,min^{-1}$
		Relative high-speed distance (Model 2)	Continuous	$m\,min^{-1}$
	Covariates	Location	Dummy variable	0 = Home, 1 = Away
		Recovery length	Dummy variable	0 = Standard, 1 = Short
		Season phase	Dummy variable	Early, middle or late season
		Opposition strength	Dummy variable	Top, middle or bottom ranked
		Result	Dummy variable	0 = Loss, 1 = Win
		Time out of play	Continuous*	Time that ball was out of play (mins)
		Possessions	Continuous	Number of possessions
		Tackles	Continuous	Number of tackles made

* Grand mean centred variable.

match location, season phase, recovery length, opposition strength, match outcome, time out of play, player involvements and player fitness status on both total and high-speed relative distance during professional rugby league match-play. These factors were selected for analysis based on findings from previous research in rugby league[7,8] and other team sports.[10–12] An improved understanding of the influence of these factors on measures of physical performance is important to enhance the interpretation of time–motion analyses and assist teams in preparing for rugby league match-play.

2. Methods

Data were collected from a cohort of 23 rugby league players (age: 25.5 ± 3.7 y; mass: 97.7 ± 11.1 kg; stature: 1.83 ± 0.06 m) from the same club during 24 games (15 wins and 9 losses) throughout the Australian National Rugby League (NRL) competition season. Matches were played in outdoor stadiums on quality natural grass fields in a variety of weather conditions. The observational group contained 6 pivots, 7 outside backs, 5 wide-running forwards and 5 hit-up forwards.[1] A total of 352 (pivots = 90; outside backs = 91; wide-running forwards = 86; hit-up forwards = 85) complete match samples were obtained for analysis. The mean (±SD) number of observations for each player was 15 ± 6 (range 6–23). Informed consent and institutional ethics approval were obtained (HREC: 2012000260).

Each match was classified according to season phase (early season, matches 1–8; mid-season, matches 9–16; or late season, matches 17–24), location (home or away), recovery length (5–6 or ≥7 days between matches), opposition strength (top five, middle five or bottom five according to final ladder position) and result (won or lost). The mean (±SD) match-day temperature for the three phases of the season were 26.0 ± 2.9, 18.0 ± 1.9 and 16.9 ± 2.8 °C, respectively. The total attacking involvements (i.e. gaining possession of the ball when in attack) and tackles completed by each player, as well as the total amount of time in which the ball was out of play during each match was obtained from a commercial statistics provider (Prozone, Sydney, Australia). Individual player aerobic fitness status was obtained from a 1.2-km shuttle run test, which is highly correlated with other field tests of aerobic capacity in team sport athletes.[13] The test involved continuous return shuttle running over 20 m, 40 m and 60 m intervals, with this sequence repeated five times to achieve a total distance of 1.2 km during the test. The time to complete the test was recorded with a stop watch and used to calculate the maximal running speed (MRS; $m\,s^{-1}$).[13] The 1.2 km shuttle run test was conducted on a quality natural grass playing surface during pre-season training prior to the start of the competition season.

Player movements during games were measured using GPS units which supplement 5 Hz GPS sampling rate data by interpolating GPS bearing data at 10 Hz (SPI-Pro X, GPSports, Canberra, Australia). The units were placed into a customised pouch in the jersey located between the scapulae of the player. The SPI-Pro X devices provide acceptable validity and reliability for measuring movements over long distances at low speeds, however, they are less precise when assessing short, high speed activities.[14] Each player wore the same GPS unit for each match during the season to minimise inter-unit error. Following each match, the GPS data were analysed using the TeamAMS proprietary software (version R1.2013.18). The match files were cleaned so that only data recorded when the player was on the field was retained for further analysis. The total and high-speed running distances (HSR; >14.4 $km\,h^{-1}$) were divided by total playing time to obtain the relative total ($m\,min^{-1}$) and high-speed distances (HSR $m\,min^{-1}$), respectively.[15]

A 3-level linear mixed model was used to examine the effects of match and player characteristics on relative distances covered during match-play (Table 1). The study design located units of analysis (individual player match sample) nested in clusters of units (player), which were nested in larger clusters of clusters (position group). Linear mixed models may involve both fixed effects (which describe the relationship between the dependent variable and covariates for an entire population) and random effects (which are associated with a random factor and usually represent random deviations from relationships described by fixed effects). Random effects can exist as either random intercepts or random coefficients in a linear mixed model.[16] Two separate linear mixed models were constructed to examine the influence of various level 1 and 2 covariates on relative total (Model 1) and HSR (Model 2) distances during match-play. The relative total and HSR distances were log transformed prior to analysis to provide differences as a percentage of the mean.[17] Random factors were included in the model to investigate deviations for players and position groups from the overall fixed intercept and fixed coefficients.

A 'step-up' model construction strategy was employed, beginning with an "unconditional" model containing only a fixed intercept and level 2 and 3 random factors.[16] The model was then developed by adding each single level 1 fixed effect, followed by level 2 fixed effects. Each single fixed effect was retained if it demonstrated statistical significance ($p < 0.05$) and improved the model information criteria compared to the previous model as determined by a likelihood ratio test. Level 1 and 2 fixed effects were also tested for random coefficient effects by comparing a model containing the random effect to that containing the fixed effect for each covariate. Both time out of play and fitness score were grand-mean centred. The intra-class correlation coefficient