Journal of Science and Medicine in Sport 18 (2015) 219–224

Contents lists available at ScienceDirect

Journal of Science and Medicine in Sport

journal homepage: www.elsevier.com/locate/jsams

Original research

Metabolic power and energetic costs of professional Australian Football match-play

Aaron J. Coutts[a,b,*], Thomas Kempton[a], Courtney Sullivan[a,b], Johann Bilsborough[a,b], Justin Cordy[b], Ermanno Rampinini[c,d]

[a] *Sport & Exercise Discipline Group, Faculty of Health, University of Technology Sydney (UTS), Australia*
[b] *Carlton Football Club, Australia*
[c] *Human Performance Laboratory, MAPEI Sport Research Center, Italy*
[d] *Department of Sport, Nutrition and Health Sciences, Faculty of Exercise Sciences, Università degli Studi di Milano, Italy*

ARTICLE INFO

Article history:
Received 5 September 2013
Received in revised form
31 December 2013
Accepted 1 February 2014
Available online 10 February 2014

Keywords:
Energy cost
Match analysis
Microtechnology
GPS
Accelerations

ABSTRACT

Objectives: To compare the metabolic power demands between positional groups, and examine temporal changes in these parameters during Australian Football match-play.
Design: Longitudinal observational study.
Methods: Global positioning system data were collected from 39 Australian Football players from the same club during 19 Australian Football League competition games over two seasons. A total of 342 complete match samples were obtained for analysis. Players were categorised into one of six positional groups: tall backs, mobile backs, midfielders, tall forwards, mobile forwards and rucks. Instantaneous raw velocity data obtained from the global positioning system units was exported to a customised spreadsheet which provided estimations of both speed-based (e.g. total and high-speed running distance) and derived metabolic power and energy expenditure variables (e.g. average metabolic power, high-power distance, total energy expenditure).
Results: There were significant differences between positional groups for both speed-based and metabolic power indices, with midfielders covering more total and high-speed distance, as well as greater average and overall energy expenditure compared to other positions (all $p < 0.001$). There were reductions in total, high-speed, and high-power distance, as well as average metabolic power throughout the match (all $p < 0.001$).
Conclusions: Positional differences exist for both metabolic power and traditional running based variables. Generally, midfielders, followed by mobile forwards and mobile backs had greater activity profiles compared to other position groups. We observed that the reductions in most metabolic power variables during the course of the match are comparable to traditional running based metrics. This study demonstrates that metabolic power data may contribute to our understanding of the physical demands of Australian Football.

1. Introduction

Australian Football is a physically demanding, high-intensity intermittent team sport. Time–motion analyses of Australian Football League (AFL) competition matches are now common as the use of global positioning system (GPS) technology is widespread throughout the League. Indeed, several studies have examined the physical demands of AFL competition match-play, particularly with reference to playing position,[1] match outcome,[2] player ability,[3] match-to-match variability[4] and match-related fatigue.[5] These studies have used common match activity profile metrics such as total distance, high speed running (HSR) and sprint activities. More recently, investigations have shown that acceleration efforts may also contribute to the match demands of Australian Football; however, this is yet to be empirically assessed.[6,7] Collectively, these applied match analysis studies have assisted in developing our understanding of the physical demands associated with competitive match-play.

Recent research from professional soccer has shown that metabolic power calculations can estimate the power output and energetic costs of intermittent running.[8,9] These investigations provide additional insight to previous studies which

* Corresponding author.
E-mail address: aaron.coutts@uts.edu.au (A.J. Coutts).

http://dx.doi.org/10.1016/j.jsams.2014.02.003
1440-2440/

have employed traditional time–motion analyses of the activity demands of training and match-play.[8,9] These metabolic power calculations are based on a theoretical model[10] that allows the estimation of the energetic cost of accelerations and decelerations during intermittent running, and can be applied to a variety of sports involving similar activity profiles. Briefly, the model considers accelerated running on a flat surface to be metabolically equivalent to incline running at a constant velocity, where the angle of the incline is equal to the extent of forward acceleration. This method provides an "equivalent slope" which is used to calculate an instantaneous measure of the energy cost of accelerated running and an estimate of metabolic power output. In contrast, traditional time–motion analyses report variables based on distances travelled in specific speed zones such as higher speed running ($\gtrsim$15 km h^{-1}) and total distance which do not account for the high energetic cost of these accelerations and decelerations.[11] Whilst no studies have directly validated this method for estimating energy cost and metabolic power, the approach has been reported to provide energy cost estimates similar to directly determined measures.[9] Moreover, Manzi et al.[12] recently reported large to very large correlations between aerobic fitness variables and metabolic power estimates of HP distance during Serie A soccer matches in 17 professional Italian soccer players, providing evidence for concurrent validity of this novel approach. Accordingly, this new has been suggested to be superior the traditional time–motion analysis variables as it provides a better estimate of the overall energy demands of team sport activities. This new approach can be used to complement traditional time–motion analysis approaches to provide new information on the power production, metabolic costs and match-related fatigue profiles in team sports such as Australian Football. In particular, this information may assist practitioners better understand of the positional demands of competition, the distribution of work during match-play and the energy requirements following match-play and training.

While this approach has been previously applied to soccer competition[13] and training,[9] no studies to date have investigated the metabolic power demands of AFL match-play. Moreover, no studies have applied this method to examine match-related fatigue in team sports such as Australian Football. Therefore, the aims of this study were to: (1) describe the metabolic demands of AFL match-play for different position groups; (2) examine temporal changes in metabolic power indices during a match; and (3) compare the match activity profile information from traditional speed-zone methods with those derived from metabolic power calculations.

2. Methods

Data were collected from 39 AF players (age: 24.6 ± 2.9 y; mass: 88.7 ± 8.7 kg; stature: 188.4 ± 7.2 cm) from the same club during 19 AFL competition games over two seasons. A total of 342 player match files were obtained for analysis. The mean (±SD) number of observations for each player was 8.8 ± 5.4 (range 1–18). Players were categorised into one of six positional groups, depending on where they played the majority of game time: tall backs, mobile backs, midfielders, tall forwards, mobile forwards and rucks.[1] The total match observations for each positional group were 35, 70, 145, 23, 48 and 21 respectively. Informed consent and institutional ethics approval were obtained prior to testing.

Player movements during the matches were measured using portable GPS systems (Team Sport 2.5, Firmware 6.54, Catapult Innovations, 10 Hz Melbourne, Australia). The GPS unit was fitted within a custom made pouch that was positioned between the scapulae in each player's jersey prior to the match. All players wore the same GPS unit for each match during the season to minimise inter-unit error.[13–15] The reliability of these GPS devices has previously been reported.[13,16,17]

Following each match, GPS data were downloaded using the same proprietary software (Catapult Sprint v5.0.6). Each file was trimmed so that only data recorded during each quarter when the player was on the field was included for further analysis. The proprietary software provided instantaneous raw velocity data at 0.1 s intervals, which was then exported and placed in a customised Microsoft Excel spreadsheet (Microsoft, Redmond, USA). The spreadsheet calculated the distance covered in the following categories; total distance; high-speed running (>14.4 km h^{-1}, HSR); very high-speed running (>19.8 km h^{-1}, VHSR); and sprinting (>24.0 km h^{-1}, Sprint). Acceleration and deceleration efforts were classified as two consecutive samples (0.2 s) exceeding the threshold of 2.78 m s^2 and 2.78 m s^2, respectively.[18] The metabolic power equations for estimating instantaneous energy cost and metabolic power,[9,10] were integrated into the spreadsheet and formed the basis for all variables related to metabolic power. The calculations were used to estimate average metabolic power (W kg^{-1}, P_{met}) and total energy expenditure (kJ kg^{-1}), as well as the distance (m), time (min) and energy expenditure (kJ kg^{-1}) produced above high power threshold (>20 W kg^{-1}, HP). Calculations were provided for the equivalent distance (ED), which represents the equivalent steady state distance required match the estimated energy expenditure during exercise; and the equivalent distance index (EDI) representing the ratio between ED and total distance.[9]

The assumptions of normality were verified prior to parametric statistical analysis. Multivariate analysis of variance (MANOVA) was used to compare differences in physical performance variables between positional groups (6) and playing quarter (4). When significant main effects were observed, Scheffe's post hoc test was applied. Standardised effect sizes (ES) were calculated with <0.2, 0.21–0.6, 0.61–1.20, 1.21–2.00 and 2.01–4.0 representing trivial, small, moderate, large and very large differences, respectively.[19] Statistical analyses were conducted using Statistica software package (StatSoft. Inc., Tulsa, USA) or Microsoft Excel (Microsoft, Redmond, CA). All data are reported as mean and 95% confidence interval (CI) unless otherwise stated. Statistical significance was set at $p < 0.05$.

3. Results

Selected distance and metabolic power variables for each playing position are shown in Table 1. MANOVA revealed significant main effects for playing position ($F = 12.8$, $p < 0.001$). Post hoc analysis revealed that midfielders covered greater total distance compared to all other positions except for mobile backs (ES = 0.72–1.39). Similarly, midfielders also had higher relative distances compared to all other positions (ES = 0.71–2.14), while higher values were observed for mobile backs compared to tall forwards (ES = 1.25) and tall backs (ES = 1.06) only. Midfielders also had greater HSR distance compared to all other positions (ES = 0.80–2.37), while mobile backs (ES = 1.04–1.65) and mobile forwards (ES = 1.16–1.73) covered more HSR distance than the other remaining position groups only. Mobile forwards covered more VHSR (ES = 0.55–4.08) and sprint distance (ES = 0.65–3.46) compared to all other positions, followed by mobile backs (ES = 0.93–2.83; 0.86–2.87) and midfielders (ES = 1.06–2.74; 0.28–2.48), which recorded higher values compared to the remaining position groups. Tall forwards had less acceleration efforts than both midfielders (ES = 1.34) and mobile backs (ES = 1.23); while tall forwards (ES = 1.46) and rucks (1.23) had fewer decelerations compared to mobile forwards. Midfielders spent less time on the field compared to both tall (ES = 1.06) and mobile backs (ES = 0.57). In contrast, the highest P_{met}, energy expenditure and equivalent distance was observed for midfield