Key words: Physiological profiling, team-sport, performance

Article submitted as a pre-print.

Power output produced during the cycling Power Profile is associated with match-running performance in elite Australian Rules Football.

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Please cite as; O'Connor F. K., et.al., (2023) Power output during the cycling Power Profile is associated with match-running performance in elite Australian Rules Football. *SportRχiv.*

Abstract

Australian Rules Football (ARF) match-play requires a high aerobic energy contribution interspersed with near-maximal sprinting. To help prepare for these demands, cycling is a widely used cross-training tool. However, relationships between cross-training performance measures and game-running outputs are unknown.

Data was collected from 50 athletes from one elite ARF club over a three-year period. The cycling Power Profile was completed at the beginning of each pre-season period (November). Mean power output (PO) for maximal efforts over 6s, 15s, 30s, 1min and 4min durations were recorded. During in-season games, total distance completed (TD), total high-speed running distance (HSR; >14.4 $km.h^{-1}$) and sprint distance (>25.0 $km.h^{-1}$) were collected via global positioning systems. Relationships between performance in the cycling Power Profile and game-running outputs were assessed utilising linear mixed models.

Higher 6s PO was associated with higher sprint distance covered in games (7.4%, 13m, $p<0.001$). Higher 15s PO was associated with higher total HSR (6.1%, 147m, $p<0.001$), but lower TD (-1.4%, -183m, $p<0.001$). Higher 30s PO was associated with reduced sprint distance (-9.0%, -16m, $p=0.04$). Higher 1min PO was associated with reduced sprint distance (-20.3%, -37m, $p<0.001$) and HSR distance (-8.0%, -194m, $p=0.02$). Higher 4min PO was associated with higher TD (10.4%, 1338m, $p<0.001$) and HSR (30.1%, 872m, $p<0.001$) but had no effect on sprint distance.

Players physiological profile characterised by the cycling Power Profile in pre-season appear to be associated with the running profile of players during in-season matches in elite Australian Football.

Introduction

Australian Rules football (ARF) is an intermittent contact sport requiring a wide range of physical attributes such as high aerobic capacity and an ability to produce high-intensity, explosive sprinting to meet the demands of competition (Ritchie et al. 2016; O'Connor 2023). For example, the mean running intensity across all positional groups during in-season match-play is ~130 $m.min^{-1}$ for a total of ~13 klm total distance per game (Janetzki et al. 2021), with peak 60s demands reported to be ~230 $m.min^{-1}$ (Delaney et al. 2017). While there is variation in the amount of external work required dependent upon playing position (Brewer et al. 2010), the activity demands of professional ARF include an average 22 ± 9 sprints totalling 328 ± 128 m of sprint distance (>25 $km.h^{-1}$) per game (Varley, Gabbett, and Aughey 2014). Moreover, professional ARF athletes complete ~82 high-intensity accelerations per game (Varley, Gabbett, and Aughey 2014) and the ability to accelerate to maximal velocities is critical to tactical execution (Burgess, Naughton, and Hopkins 2012; Robertson, Woods, and Gastin 2015; Wadley and Le Rossignol 1998). Based on the reported match demands of ARF, the ability to sustain high intensity aerobic performance interspersed with near maximal sprint efforts is critical to success.

The annual plan for elite ARF can be broadly split into pre-season, in-season and off-season periods. In the pre-season, a typical weekly micro-cycle will include 3-4 pitch-based training sessions, 3-5 resistance training sessions, along with game education, physiotherapy, mobility, recovery and professional development blocks, depending on player needs (Ritchie et al. 2020). In light of the high running demands of ARF and the congested mid-weekly schedules, the utilisation of time efficient and effective cross-training sessions are imperative. For example, in a professional environment, stationary cycling is widely utilised to optimise athlete conditioning without the physical impact loading of ‘on-legs’ training modalities such as running (O'Connor et al. 2020a; Ritchie, et al. 2016).

Team sport athletes complete a battery of performance tests at the commencement of the pre-season preparation period, that often include the Yo-Yo intermittent recovery test (Schmitz et al. 2018), and 30-15 intermittent fitness test (Buchheit and Mendez-Villanueva 2013), amongst other measures of strength, power and change of direction speed (Robertson, Woods, and Gastin 2015). While these testing protocols have been shown to effectively assess individual physical fitness characteristics (Thomas, Dawson, and Goodman 2006; Scott et al. 2015), discriminate between playing standard (Rampinini et al. 2009) and position (Michalsik, Madsen, and Aagaard 2014; Deprez et al. 2015), and are associated with match running performance (Castagna et al. 2009; Souhail et al. 2010) and promotion to elite competition among youth athletes (Robertson, Woods, and Gastin 2015; Pyne et al. 2005), little is known about the efficacy of any cycling exercise testing protocols and their relationship with game-running performance in elite team sport.

While the utility of a cycling-based testing protocol is unknown, it stands to reason that a time-efficient testing protocol that could assess individual athlete phenotypes and provide insights in to potential game-running performance would be of use to practitioners. As such, the aim of the current investigation was to determine relationships between an intermittent, maximal effort cycling (Australian Institute of Sport [AIS]) Power Profile and in-game running performance in professional Australian Rules Footballers.

Methods

Experimental approach to the problem

Our study design involved elite Australian Rules Footballers completing the cycling Power Profile at the commencemnent of each pre-season preparation period (i.e., week 1). Match-running GPS data was obtained during all competitive elite-level competition period across the three season data collection period. Relationships were assessed between results obtained during the pre-season Power Profile testing and game-running outcomes in elite level competition games via linear mixed effects models.

Participants

A convenience sample of 50 professional male athletes (age: 22.9 ± 3.8 y, height: 188.4 ± 8.3 cm, body mass: 86.9 ± 9.4 kg, maximal aerobic speed 17.6 ± 0.8 km.h^{-1}) from one professional ARF club participated in this study. Athletes were included in the analysis if they had completed both the modified Power Profile (Quod et al. 2010) during the pre-season and competed in a minimum of three elite level in-season games in the subsequent in-season. When athletes completed the Power Profile and played in-season games across multiple annual plans/years, relationships were examined between their Power Profile results and in-game running performance from the same annual plan/year. The study was conducted in line with the declaration of Helsinki and ethical approval was granted by the Bond University Human Research Ethics Committee (DR03167).

Procedures

At the commencement of each pre-season period during the three-year data collection (i.e., in week 1), athletes completed the Power Profile cycling test in accordance with methods described previously (Quod, et al. 2010) on a stationary cycle ergometer (WattBike, Pro, United Kingdom) in a thermoneutral environment (~22 °C, ~50% RH). Participants were accustomed to completing high-intensity intervals on stationary cycle ergometers through previous cross-training conditioning sessions. The Power Profile was modified to conclude at the completion of the 4-min max effort interval (Table 1). At the completion of the test, data was downloaded utilising specialist software (Power Cycling Studio v 3.0, WattBike, United Kingdom). The mean power output for each interval was collected, and the mean of the two 6 s intervals was taken for data analysis. Power output was expressed relative to the individuals body mass (kg) for analysis ($W \cdot kg^{-1}$).

External load was recorded for each athlete during every elite level competition game across three Australian Football League (AFL) seasons. Athletes were provided with their own 10 Hz global positioning system (GPS) device (Optimeye S5, Catapult Sports, Melbourne, Australia) to avoid inter-unit measurement error (Coutts and Duffield 2010). Accuracy of measurement was obtained and included in the final analysis in accordance with previously described methods (O'Connor et al. 2019). Game data were analysed for total distance completed (TD), total high-speed running (distance > 14.4 $km \cdot h^{-1}$ [HSR]), and sprint distance (>25.0 $km \cdot h^{-1}$). There was a total of 1315 game-day GPS files in the final analysis resulting in 26.3 ± 17.0 games per player (range 3 to 61).

Statistical Analysis

Linear regression analysis (Bates et al. 2015) was used to determine relationships between: (1) Power Profile performance across each interval duration and game running outputs in the corrsponding season using the following equation;

$$y = 6s + 15s + 30s + 1\,min + 4\,min \sim Individual\ player$$

Where *y* is the external load variable of interest (e.g., Total Distance), 6s through 4 min are the mean power outputs completed during the corresponding Power Profile intervals and *Individual player* is a random effect of individual, and (2) season-to-season change in power profile performance and changes in season-to-season match running performance. Normality assumptions were validated using residual and QQ-plots, and the adequacy of the model structures were determined via residual plots and quantified using standard measures of intraclass correlations and coefficients of determination. All variables of interest in the model are shown as absolute change with confidence intervals (CI [95%]) as well as percent change from mean. Standardized regression coefficients for each variable were multiplied by the standard deviation of the change in dependent variable to obtain the absolute change in the units of measurement (Nieminen et al. 2013) allowing a standardized assessment of practical significance. All data was analysed using *R* (v. 4.1.0) and significance was set at $p < 0.05$. The datasets generated during and/or analysed during the current study are available from the corresponding author on reasonable request.

Results

Power profile performance and match-running performance

Higher mean 6 s power output was associated with an increase in sprint distance completed during in-season games (7.4%, 13 m, 95% CI: 7 to 19 m, $p < 0.001$).

Higher mean 15 s power output was associated with an increase in HSR metres during games (6.1%, 147 m, 95% CI: 72 to 223 m, $p < 0.001$). Conversely, an increase in mean 15 s power output was associated with a decrease in total distance covered during games (-1.4%, -183 m, 95% CI: -29 m to -336 m, $p < 0.001$).

Higher mean 30 s power output was associated with a decrease in distance completed >25 $km.h^{-1}$ during games (-9.0%, -16 m, 95% CI: -1 m to -32 m, $p = 0.04$).

Higher mean 1 min power output was associated with a decrease in sprint distance (-20.3%, -37 m, 95% CI: -15 to -58 m, $p < 0.001$), and total HSR meters during games (-8.0%, -194 m, 95% CI: -34 to -354 m, $p = 0.02$).

Higher mean 4 min power output was associated with an increase in total distance covered (10.4%, 1338 m, 95% CI: 1003 to 1672 m, $p < 0.001$) and total HSR meters (30.1%, 872 m, 95% CI: 707 to 1036 m, $p < 0.001$).

Season-to-season change

There was no change in individual GPS-based game running output measures across the experimental period (all $p > 0.05$). Mean 6 s and 1 min PO was higher in Season 3 compared to Season 1 ($p = 0.03$), and mean 4 min PO was higher in Season 3 ($p = 0.007$) and Season 2 ($p = 0.001$) compared to Season 1 (Table 2).

Discussion

This study aimed to determine the relationship between performance of an intermittent, maximal effort cycling protocol conducted during the pre-season and subsequent in-game running performance in professional ARF athletes. The main findings show that individuals who produced higher sprint/anaerobic power outputs during the Power Profile completed more distance at sprint velocities (>25 $km.h^{-1}$) during games, while higher performance in the predominantly aerobic 4min interval during the Power Profile resulted in individuals completing more total distance, and more HSR distance (>14.4 $km.h^{-1}$) during games. The data presented in this manuscript show that an 'off-feet' performance test designed to characterise cycling phenotype displays significant relationships with game-running profiles in a high-intensity, intermittent team-sport.

Our data show relationships between sprint and aerobic cycling performance in the Power Profile and accumulation of sprint distance, and total distance and high-speed running, respectively, in elite ARF players. Specifically, we show that higher power output during the 6s and 15s intervals within the Power Profile was associated with in greater distance completed >25 $km.h^{-1}$ during elite ARF games, suggesting athletes who display a 'sprint and power' phenotype during pre-season testing will display similar characteristics during in-season games. Our findings are in support of Morris et.al. (Morris, Weber, and Netto 2020) who showed countermovement jump performance is related to 40 m sprint performance in elite ARF athletes (Morris, Weber, and Netto 2020), suggesting other non-specific (non-running) tests of power can be utilised to indicate ARF match running performance. Together, these findings support the use of performance outcomes from AIS cycling Power Profile to discriminate between athlete phenotype and game-running performance of professional ARF athletes.

The negative relationships between the 30s and 1min max effort intervals of the Power Profile and HSR and Sprint distance during the current study was unexpected given the high-intensity, intermittent nature of ARF (O'Connor et al. 2020b). However, our results support previous studies within team sport cohorts that show poor relationships between repeated effort cycling performance and metabolic demands of more 'sport-specific' actions (Twist, Bott, and Highton

2022). Moreover, these findings could be reflective of the testing protocols employed and the classification and division of speed 'zones' in the present study. Indeed, standardised running speed 'zones' may not be particularly reflective of the high-intensity accelerations and movements that are required in intermittent team sports (Polglaze et al. 2018) such as ARF. Intuitively, the currently utilised speed 'zones' to classify team-sport running performance may be more reflective of aerobic and anaerobic ability independently as opposed to an ability to produce and repeat high-intensity efforts. For example, distance covered at velocities greater than 25 $km.h^{-1}$ would require a large amount of anaerobic energy contribution for a group of athletes whose mean maximal aerobic speed is ~17.0 $km.h^{-1}$. Conversely, distance covered at ~15 $km.h^{-1}$ is predominantly aerobic for this group of athletes.

Practical applications

The data in the current study highlight the relationships between the AIS cycling Power Profile to indicate subsequent in-game running performance. This information can be used by practitioners in the field to highlight individuals' who may produce a higher volumes of in-game running prior to the commencement of competitive matches, while also characterising individual physiological strengths and weaknesses that can be used to inform subsequent programming practices.

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Table 1. Modified Power Profile completed at the beginning of each pre-season preparation period.

Interval	Work (s)	Rest (s)
1	6	54
2	6	174
3	15	225
4	30	330
5	60	480
6	240	-

Table 2. Descriptive Statistics across the experimental period

Season	Distance	14.4 - 17.9 km.h^{-1} (m)	18.0 – 24.9 km.h^{-1} (m)	> 25.0 km.h^{-1} (m)	HSR (m)	6 s PO (W.kg)	15 s PO (W.kg)	30 s PO (W.kg)	1 min PO (W.kg)	4 min PO (W.kg)
1	12533 ± 1136	1830 ± 423	1277 ± 455	173 ± 87	3280 ± 774	14.6 ± 1.4	12.3 ± 1.1	8.5 ± 0.8	5.4 ± 0.5	3.3 ± 0.4
2	12946 ± 990	1647 ± 356	1644 ± 432**	172 ± 84	3463 ± 765	15.3 ± 1.4	12.4 ± 1.3	8.6 ± 0.8	5.7 ± 0.6	3.5 ± 0.4*
3	12823 ± 865	1600 ± 308*	1635 ± 425**	173 ± 73	3408 ± 726	15.4 ± 1.5*	12.5 ± 1.1	8.7 ± 0.8	5.8 ± 0.5*	3.6 ± 0.4**

* denotes significantly different from 2016 season. $^{*}p < 0.05$, $^{**}p < 0.01$

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