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Muscle Glycogen Utilisation during an Australian Rules Football Game

Submission Type: Case-Study

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Abstract

Purpose: To better understand the carbohydrate (CHO) requirement of Australian Football (AF) match play by quantifying muscle glycogen utilisation during an in-season AF match.

Methods: After a 24 h CHO loading protocol of 8 g/kg and 2 g/kg in the pre-match meal, two elite male forward players had biopsies sampled from *m. vastus lateralis* before and after participation in a South Australian Football League game. Player A (87.2kg) consumed water only during match play whereas player B (87.6kg) consumed 88 g CHO via CHO gels. External load was quantified using global positioning system technology.

Results: Player A completed more minutes on the ground (115 *vs.* 98 min) and covered greater total distance (12.2 *vs.* 11.2 km) than Player B, though with similar high-speed running (837 *vs.* 1070 m) and sprinting (135 *vs.* 138 m), respectively. Muscle glycogen decreased by 66% in Player A (Pre-: 656, Post-: 223 $mmol·kg^{-1}$ dw) and 24% in Player B (Pre-: 544, Post-: 416 $mmol·kg^{-1}$ dw), respectively.

Conclusion: Pre-match CHO loading elevated muscle glycogen concentrations (i.e. >500 $mmol.kg^{-1}$ dw), the magnitude of which appears sufficient to meet the metabolic demands of elite AF match play. The glycogen cost of AF match play may be greater than soccer and rugby and CHO feeding may also spare muscle glycogen use. Further studies using larger sample sizes are now required to quantify the inter-individual variability of glycogen cost of match play (including muscle and fibre-type specific responses) as well examine potential metabolic and ergogenic effects of CHO feeding.

Keywords: carbohydrate loading, vastus lateralis, AF, high speed running

Introduction

Invasive team sports such as soccer[1,2], rugby league[2] and Australian Football (AF)[2,3] are characterised by high-intensity (>19.8km.h^{-1}) intermittent activity profiles. Given the duration of activity (i.e. 80-120 minutes) and high-intensity intermittent profiles, muscle glycogen is considered as the predominant energy substrate to support the metabolic demands of match play[4,5]. In relation to soccer, it has been reported that match-play in elite Danish soccer players[5] depletes muscle glycogen concentration by a magnitude of 50% and requires a glycogen cost of approximately 200 mmol·kg^{-1} dw. We also observed similar absolute glycogen utilisation and relative depletion rates in English professional rugby league players during competitive match play[6]. Nonetheless, in the absence of a controlled carbohydrate (CHO) loading protocol, it is noteworthy that pre-match muscle glycogen concentrations in team sport athletes may range from 300-600 mmol·kg^{-1} dw[7] and that approximately 50% of muscle fibres are classified as empty or partially empty after soccer match play, thus having potential implications for high-intensity physical performance late in the match. Indeed, in relation to physical performance, it was recognised as early as the 1970s[8] that commencing match play with reduced pre-exercise muscle concentration (i.e. < 200 mmol·kg^{-1} dw) reduces total distance covered by 25% when compared with higher pre-match muscle glycogen availability (i.e. > 400 mmol·kg^{-1} dw).

Given the longer duration and greater proportion of time spent at high-intensity workloads in AF match play[2,3] versus both soccer[1,2] and rugby[2], it could be suggested that the CHO requirements for AF players are increased accordingly. Indeed, high velocity running was reported to be significantly greater in AF (1322m) versus rugby league (327m) and soccer (517m)[2]. To the authors' knowledge, however, no researchers have yet quantified the muscle glycogen cost of AF match play in elite players. The aim of the present case-study was to quantify glycogen use in *m. vastus lateralis* from two elite male AF players after participation in a South Australian Football League game.

Methods

Subjects

Two male forward players from a South Australian Football League (SANFL) list (see Table 1) volunteered to take part in the study. The study was conducted according to the

Declaration of Helsinki and was approved by the Human Research Ethics Committee of Australian Catholic University Melbourne.

Design

In a case-study design, muscle biopsies were obtained from *m. vastus lateralis* before and after participation in a competitive SANFL league game undertaken in August 2017. Quantification of external loading during match play was assessed via global positioning system (GPS) technology.

Dietary Controls. In the day prior to match play, each player consumed a prescribed CHO loading diet providing CHO, protein and fat intakes corresponding to 8 g/kg, 2 g/kg and 1 g/kg body mass, respectively, based on contemporary guidelines of Thomas and colleagues[9]. At 4 hours prior to match play, each player also consumed a pre-match meal providing 2 g/kg CHO, 0.2 g/kg protein and 0.3 g/kg fat. During match play, players were able to consume fluids and sports foods at opportunities that were both predictable (between quarters) and random (rotation on the bench, access to trainer on the ground when the ball is not in play). On such occasions; Player A consumed water only whereas Player B also consumed an additional 88 g of CHO in the form of four isotonic CHO gels (SiS GO Gels, Nelson, UK) consumed at the quarter time breaks (~20-minute intervals during the game).

Muscle Biopsies. Muscle biopsies (100 mg) were sampled from *m. vastus lateralis* at 60 minutes prior to the beginning of the game (i.e. prior to the warm-up period) and within 10 minutes of completion of match play participation. Biopsies were obtained under local anesthesia (1% Xylocaine) using a Bergstrom biopsy needle and immediately frozen in liquid nitrogen for later analysis. Approximately 3 mg of freeze-dried muscle tissue was powdered and dissected free of all visible non-muscle tissue. Powered muscle tissue was then mixed with 250 µl of 2 M HCl, incubated at 95^{o}C for 2 hours (agitated gently every 20 min), and then neutralized with 750µl of 0.66 M NaOH. Glycogen concentration was subsequently assayed in triplicate via enzymatic analysis with flurometric detection. Muscle glycogen values were expressed as millimoles per kilograms dry weight (mmol·kg^{-1} dw).

GPS Analysis. Both players wore a portable micro-technology device (Optimeye S5, Catapult Innovations, Melbourne, Australia) which recorded activity profile data. The portable device was worn inside a purpose built elastic vest, positioned across the upper back between the scapula. Each device was activated 30-minutes prior to the start of the game to allow acquisition of satellite signal and lock (>8 satellites). Satellite data sampled at 10 Hz provided measures of duration, total distance, average speed and distance covered within four specific velocity bands corresponding to: jogging (2-3.9 $m.s^2$), running (4-5.4 $m.s^2$), high-speed running (5.5-6.9 $m.s^2$) and sprinting (7 $m.s^2$). These speed zones are similar to those previously reported in soccer[1] and allow for direct comparisons between football codes. At the conclusion of the match, data were downloaded and analyzed using (Openfield version 11.12, Catapult Innovations).

Results

Subject characteristics, external workload, muscle glycogen utilisation and CHO intake are presented in Table 1. Individual data are presented for both Player A and B.

Discussion

The aim of the present case-study was to quantify muscle glycogen utilisation during AF match play. We studied two elite male AF players during a competitive match from the South Australian Football League. Our data demonstrate that a standardised one day dietary CHO loading protocol of 8 g/kg and 2 g/kg in the pre-match meal elevates muscle glycogen concentration (i.e. >500 $mmol.kg^{-1}$ dw) to a magnitude that is sufficient to fuel the metabolic demands of AF match play.

In relation to the external loads reported here, we observed similar loading profiles to that previously reported in elite AF match play where larger sample sizes (e.g. 39 players) have been studied[3]. This is the case for parameters such as total distance, average speed, high-intensity running and sprinting. The between player differences in such parameters are also similar to those previously reported[3]. Despite only studying two forward players, we are confident that the external loads reported here are therefore representative of the customary loads experienced in AF match play from a wider sample of teams and players, though we acknowledge that load differences between playing positions are to be expected[3].

In accordance with a higher workload, our data suggest that the glycogen cost of AF match play (e.g. Player A utilised 433 $mmol.kg^{-1}$ dw) may be greater than that reported in soccer[5,7] and rugby match play[6] where approximately 200 $mmol.kg^{-1}$ dw was utilised in both instances. Such differences in absolute glycogen cost are likely due to greater duration of activity and time spent in higher intensity threshold zones[10]. In contrast to Player A, Player B experienced less total glycogen use (138 mmol.kg^{-1} dw). While such inter-individual variation in glycogen use may be due to differences in total distance covered, duration, pre-match muscle glycogen concentrations[11], training status and muscle oxidative capacity[12], it is noteworthy that Player B also consumed an additional 88 g of CHO during match play. As such, differences in glycogen use between players may also be due, in part, to a potential muscle glycogen sparing effect of CHO feeding, an effect that has been reported previously in *m. vastus lateralis* during running[13]. Indeed, the game characteristics of AF support a more aggressive approach to CHO intake during play than is reported by elite soccer players[2], with opportunities for fuel replacement during scheduled breaks between quarters and time spent on the interchange bench. Nonetheless, we acknowledge that randomised control trials incorporating larger sample sizes are now required to verify any potential metabolic or ergogenic effect of CHO feeding during competitive match play. Additionally, glycogen use in specific muscles (e.g. gastrocnemius versus vastus lateralis), muscle fibre types and intra-cellular storage pools could also be quantified using transmission electron microscopy[14,15]. We also acknowledge that the glycogen utilisation observed here is also reflective of those activities undertaken during the warm-up period. As such, future studies could also sample biopsies in the minutes prior to match play and at the end of each quarter to further characterise both the total absolute use and rates of glycogen use as the match progresses.

Practical Applications

Pre-match muscle glycogen concentration > 500 mmol.kg^{-1} dw (as achieved via CHO loading of 8 g/kg) is sufficient to fuel the physical demands of elite forward AF match play. Given the apparently greater muscle glycogen cost of AF match-play compared to soccer and rugby, sport physiologists and nutritionists should ensure that AF players consume sufficient dietary CHO intake (likely > 6 g/kg) in the 24 hours prior to participation in match play.

Conclusion

We provide novel data by reporting muscle glycogen utilisation in *m. vastus lateralis* from two elite male AF forward players during competitive match play. Our data suggest that total glycogen use is greater than that reported in elite players from other invasive team sports, such as soccer and rugby. Additionally, these data suggest that CHO loading with 8 g/kg body mass is sufficient to meet the metabolic demands of AF match play and that previous suggestions of 10-12 g/kg body (for athletes involved in intermittent exercise > 90 minutes) mass may not be necessary for this population. Further studies are now required to quantify the inter-individual variability of glycogen use as well as examine any potential metabolic and ergogenic effects of CHO feedings during match play.

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Table 1 – Subject characteristics, external workload, muscle glycogen utilisation and in-game CHO intake in Player A and B.

	Player A	**Player B**
Playing Position	Forward	Forward
Age (years)	22	27
Body Mass (kg)	87.2	87.6
Height (m)	1.88	1.82
Warm Up Duration (min)	12	12
Distance (m)	1478	1501
High Speed Running (m) 5.5-6.9 $m.s^2$	156	159
Sprinting (m) >7 $m.s^2$	23	31
Match Play Duration (min)	115	98
Number of Rotations	2	4
Average Speed (m/min)	106	114
Total Distance (m)	12229	11182
Walking (m) 0.1-1.9 $m.s^2$	3801	2801
Jogging (m) 2-3.9 $m.s^2$	5231	4718
Running (m) 4-5.4 $m.s^2$	2180	2396
High Speed Running (m) 5.5-6.9 $m.s^2$	837	1070
Sprinting (m) >7 $m.s^2$	135	138
Pre-Match Glycogen ($mmol.kg^{-1}$ dw)	656	544
Post-Match Glycogen ($mmol.kg^{-1}$ dw)	223	416
Total Glycogen Utilisation ($mmol.kg^{-1}$ dw)	433	138
Total Exogenous CHO Consumed (g)	0	88
Exogenous CHO (g/h)	0	54
Exogenous CHO (g/min)	0	0.9