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Original Article

Temporal changes in physiological and performance responses across game-specific simulated basketball activity

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Abstract

Purpose: The aims of this study were to: (1) provide a comprehensive physiological profile of simulated basketball activity and (2) identify temporal changes in player responses in controlled settings.
Methods: State-level male basketball players ($n = 10$) completed 4×10-min simulated quarters of basketball activity using a reliable and valid court-based test. A range of physiological (ratings of perceived exertion, blood lactate concentration ([BLa^-]), blood glucose concentration ([BGlu]), heart rate (HR), and hydration) and physical (performance and fatigue indicators for sprint, circuit, and jump activity) measures were collected across testing.
Results: Significantly reduced [BLa^-] (6.19 ± 2.30 *vs.* 4.57 ± 2.33 mmol/L; $p = 0.016$) and [BGlu] (6.91 ± 1.57 *vs.* 5.25 ± 0.81 mmol/L; $p = 0.009$) were evident in the second half. A mean HR of 180.1 ± 5.7 beats/min (90.8% ± 4.0% HR_{max}) was observed, with a significant increase in vigorous activity (77%–95% HR_{max}) (13.50 ± 6.75 *vs.* 11.31 ± 6.91 min; $p = 0.024$) and *moderate* decrease in near-maximal activity (>95% HR_{max}) (7.24 ± 7.45 *vs.* 5.01 ± 7.20 min) in the second half. *Small* increases in performance times accompanied by a significantly lower circuit decrement (11.67 ± 5.55 *vs.* 7.30 ± 2.16%; $p = 0.032$) were apparent in the second half.
Conclusion: These data indicate basketball activity imposes higher physiological demands than previously thought and temporal changes in responses might be due to adapted pacing strategies as well as fatigue-mediated mechanisms.

Keywords: Cardiovascular; Game-play; Hydration; RPE; Simulation; Team sports

1. Introduction

In-game physiological measurements provide an important understanding of the energetic, systemic, and physical bases of movement in team sports and can be used to optimize player preparedness for competition. The physiological demands of basketball game-play have historically been inferred through time–motion analysis (TMA) studies using video-based techniques.[1–4] Time–motion investigations suggest that basketball game-play is comprised of short bouts of high-intensity movements interspersed with longer, lower intensity periods, thus stressing anaerobic and aerobic metabolic pathways.[3,4] However, TMA approaches are only able to describe the external movement demands of basketball game-play and, as such, omit important insight regarding internal, player responses.

To date, limited data exist detailing the internal, physiological responses during basketball game-play, with many studies examining non-competitive, scrimmage scenarios.[5–7] The available physiological data collected during actual basketball game-play have largely been limited to heart rate (HR) responses, either in isolation[8–10] or combined with blood lactate concentration ([BLa^-]) measurement.[2,3,11–13] Furthermore, mean HR (percent maximum HR (% HR_{max})) responses between 80% and 94% HR_{max} and [BLa^-] responses between 3.2 and 6.6 mmol/L^{-1} have been observed across various basketball competitions. These physiological data support TMA findings that describe basketball game-play as intermittent, with high-intensity bouts.[2,3,8,9,11,12]

The limited physiological data collected during basketball game-play are likely due to restrictions associated with collecting player responses across competition.[11] The unplanned nature

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of game-play, player preferences, and competition regulations prevent the requisite player access for discrete (e.g., blood sampling, player ratings, performance tests) and continuous (e.g., HR data using telemetry, metabolic data using portable open-circuit spirometry) measurement. These limitations make it difficult to definitively understand the physiological responses associated with basketball game-play and to quantify fatigue-related changes in players. To date, researchers have been restricted to making indirect suppositions regarding player fatigue during game-play as many confounders go unaccounted for when reporting on player demands, including playing pace,[3,14] stoppages,[2,15] player substitutions,[15] and team formations.[2] To overcome these limitations, team sport researchers are increasingly utilizing field-based simulation tests to replicate competition demands.[16–19]

Simulation tests permit greater control over the physical stimuli imposed upon players, while providing the opportunity to regularly assess physiological and performance measures. A wider physiological assessment is especially important in understanding temporal player fatigue given the multifaceted nature of these responses.[20] More precisely, dehydration,[21,22] reduced blood glucose and muscle glycogen levels,[20] perceptual factors,[22] and increased reliance on anaerobic metabolic pathways[20,23] are some of the mechanisms which have been theorized to contribute to fatigue-related declines in performance during team sport game-play. At present, a controlled physiological assessment during basketball-specific activity is absent in the literature. Therefore, this study aims to (1) provide a comprehensive physiological profile of simulated basketball activity and (2) identify temporal changes in physiological and physical responses.

2. Methods

2.1. Participants

Ten state-level junior male representative basketball players volunteered to take part in this study (age: 16.6 ± 1.1 years; height: 182.4 ± 4.3 cm; body mass: 68.3 ± 10.2 kg; body fat: 10.6% ± 2.2%; VO_{2max}: 48.3 ± 5.0 mL/kg/min; competitive basketball history: 6.4 ± 2.3 years; playing position: guards ($n = 4$), forwards ($n = 4$), centers ($n = 2$)). Prior to study commencement, all participants were deemed healthy through a pre-exercise screening questionnaire[24] and provided personal and guardian informed consent (if under 18 years of age). All testing was conducted mid-season with participants completing 5.4 ± 1.9 h of structured training per week (3 sessions) leading into and during the testing period. Participants were instructed to maintain normal diet patterns, including their typical pre-game meal 2–3 h before testing, and were asked to refrain from strenuous activity (above a "jogging" intensity) for 24 h prior to the commencement of each testing session. Participants attended 3 separate testing sessions with a minimum of 3 days between each session. All procedures in this study were approved by the Central Queensland University Human Research Ethics Committee.

2.2. Familiarization

During the first session, participants were familiarized with the physiological measurements and test protocols to be completed during all testing. Familiarization included: (1) demonstration and collection of a capillary blood sample; (2) use of the Borg 6–20 Rating of Perceived Exertion scale;[25] (3) fitting of the HR monitors; (4) partaking in treadmill activity at different speeds fitted with the portable metabolic analyzer to be used during the graded maximal treadmill test; and (5) performance of the Basketball Exercise Simulation Test (BEST), involving verbal explanation, physical demonstration, completion of circuits at lower intensities, and completion of circuits at requisite intensities until comfortable.[26]

2.3. Demographic and maximal aerobic capacity assessment

At the second testing session, participants attended an environmentally-controlled exercise physiology laboratory (temperature: 23.9% ± 1.4°C; humidity: 52.8% ± 6.5%; atmospheric pressure: 755.9 ± 1.7 mmHg). During this session, anthropometric measures were collected on all participants including stature (portable stadiometer; Blaydon, Sydney, NSW, Australia), body mass (electronic scales, BWB-600; Tanita Corporation, Tokyo, Japan), and skinfold measures. Skinfold measurements were taken at the abdomen, triceps, and front thigh sites using Harpenden skinfold callipers (British Indicators Ltd., West Sussex, UK), and body composition was estimated using a validated prediction equation.[27] Prior to completing a maximal treadmill exercise test, participants were fitted with the metabolic analyzer (Oxycon Pro; Jaeger, Wuerzburg, Germany), which calculated expired gas parameters across 15-s epochs. Furthermore, Polar Team2 Pro HR monitors (Polar Electro, Kempele, Finland) were fitted to each participant to continuously measure HR responses across 1-s intervals during testing. Participants completed the maximal treadmill test (TMX425; Full Vision Inc., Newton, KS, USA) which consisted of 3-min stages. Following a standardized warm-up consisting of jogging at 8 km/h for 3 min and variable intensities for 2 min, participants commenced the first stage of the test jogging at 9 km/h. Following the first stage, participants had 1 min rest on the treadmill to allow for RPE measurement and [BLa^-] determination. Each stage thereafter progressed in the same manner, with running speed increasing by 2 km/h per stage until test completion.

2.4. The Basketball Exercise Simulation Test (BEST)

The final testing was conducted between 10:00 a.m. and 3:00 p.m. for all participants. During the final testing session, participants completed a standardized 15-min warm-up consisting of low-intensity jogging, whole-body dynamic and static stretches, and brief bouts of high-intensity running,[28] before completing the BEST. The BEST contained 4 × 10-min quarters with 3 min rest between quarters, except at the half-time point, where a 15-min rest period was applied. During inter-quarter breaks, participants sat passively for RPE measurement and capillary blood sampling for 3 min, and during the half-time break, participants primarily stood passively following the initial 3 min.

The BEST is a circuit-oriented, court-based test that replicates the activity demands of male basketball competition. Each BEST circuit comprises 30 s of intermittent activity at specified intensities as previously detailed.[26,28] The different activity types and