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Original research

Differences in the acute inflammatory and glucose regulatory responses between small-sided games and cycling in sedentary, middle-aged men

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ABSTRACT

Objectives: This study compared the acute inflammatory and glucose regulatory response within and between rugby specific small-sided games and stationary cycling in sedentary, middle-aged Caucasian men.
Design: Nine middle-aged, sedentary men who were free from disease participated in 2 × 40 min exercise conditions (stationary cycling and small-sided games) in a randomised, cross-over design.
Methods: Heart rate and Rating of Perceived Exertion were collected during each bout. Venous blood was collected at fasting, 0, 30, 60 and 240 min post-exercise for measurement of glucose, insulin, cortisol and inflammatory markers including tumour necrosis factor-α, interleukin-1β, interleukin-6, interleukin-1 receptor agonist and C-reactive protein.
Results: No significant differences existed between conditions for heart rate and Rating of Perceived Exertion ($p > 0.05$). Interleukin-6 was increased immediately post-exercise in both conditions ($p < 0.05$), but greater in small-sided games at 240 min post-exercise compared with stationary cycling ($p < 0.05$). Glucose was lower in small-sided games than stationary cycling at 30 and 240 min post-exercise ($p < 0.05$). Interleukin-1receptor agonist, insulin and cortisol showed an exercise-induced increase ($p < 0.05$), with no significant differences between conditions ($p > 0.05$). Results for C-reactive protein, tumour necrosis factor-α and interleukin-1β showed no significant exercise-induced changes within or between conditions ($p > 0.05$).
Conclusions: Both small-sided games and stationary cycling conditions were sufficient to stimulate an acute anti-inflammatory response as indicated by the post-exercise elevation of interleukin-6, interleukin-1receptor agonist and cortisol. The novel findings are that an acute bout of small-sided games bout is capable of maintaining an elevated post-exercise interleukin-6 response and lowered blood glucose concentration, compared with intensity- and duration-matched stationary cycling condition.

1. Introduction

Chronic low-grade inflammation has been established as a predictor for the development of chronic diseases, such as type 2 diabetes mellitus (T2DM) and cardiovascular disease (CVD).[1] An inactive lifestyle is proposed to lead to the accumulation of adipose tissue and is accompanied by the infiltration of adipose derived pro-inflammatory proteins into the circulation.[2] Conversely, increased physical activity has been reported as an effective preventative approach to reduce the inflammatory risks associated with these chronic metabolic and cardiovascular diseases.[3,4] Notably, the reduced inflammatory state from regular exercise is proposed to occur through the heightened anti-inflammatory environment induced by the acute bout.[5–7]

Acute exercise has been shown to stimulate glucose disposal and inhibit the release of pro-inflammatory cytokines.[8] Indeed, the magnitude of the acute inflammatory and glucose regulatory response tends to be dictated by the cohort (trained and untrained), the muscle mass involved to complete the mechanical work, intensity and duration of the bout.[2,9,10] Typically following exercise, the active skeletal muscle increases both cellular and circulating levels of interleukin (IL)-6.[11] This acute increase in IL-6 is transient and produced independently to pro-inflammatory cytokines (tumour necrosis factor (TNF)-α and IL-1β).[12] Moreover, IL-6 has been

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shown to be responsible for a successive rise in anti-inflammatory cytokine IL-1receptor agonist (ra) (agonist to IL-1β), hepatic synthesis of C-reactive protein (CRP), suppression of TNF-α and the release of cortisol.[5,9,12] Additionally, IL-6 has also shown to increase basal and insulin-stimulated glucose uptake in skeletal muscle via stimulation of the AMP-kinase pathway and associated increase in glucose transporter 4 (GLUT4) translocation, while the increased release of cortisol stimulates endogenous glucose production from the liver.[6,13] The increased concentration of both cortisol and IL-6 collectively work to regulate blood glucose concentration during acute exercise by maintaining equilibrium between glucose disposal and production.

Previous studies examining the acute exercise-induced inflammatory responses in sedentary populations have used gym-based methods of aerobic (cycling, running) and/or resistance (machine and free weights) exercises of differing intensities and durations.[6,10] A comparison between acute bouts of continuous cycling and intermittent full-body resistance exercises have shown a comparable post-exercise IL-6 response when matched for duration, session RPE and mean heart rate (HR).[10] These results demonstrate the integrity of either intermittent or continuous exercise in stimulating an acute inflammatory response. Notably, group aerobic training sessions are reported to be more enjoyable than individualised training, which can potentially affect adherence and sustainability of an exercise training programme.[14] Recently, soccer specific small-sided games (SSG) training has been reported to incorporate high-intensity intermittent sprints into an endurance-based event, which was highlighted as capable of inducing positive training adaptations (body composition, aerobic capacity, blood pressure, strength) either comparable to, or better than, traditional continuous training modalities such as running.[15,16] To date, previous research on the acute post-exercise inflammatory response to SSG or intermittent sprint protocols has been specific to sedentary Indigenous Australians[17] or young athletic populations.[7] A further understanding of these acute inflammatory and glucose responses in a sedentary, middle-aged population may be beneficial to justify the prescription of SSG for long-term inflammatory and glucose regulatory health benefits. Accordingly, the present study aimed to quantify and compare the acute inflammatory and glucose regulatory response within and between rugby-specific SSG and CYC conditions in sedentary, middle-aged Caucasian men. It was hypothesised that when matched for intensity and duration between the conditions a similar inflammatory and glucose regulatory response will be evident.

2. Methods

The study population comprised of 9 sedentary, middle-aged men (48.8 ± 1.7 y) who were not clinically diagnosed with any pre-existing cardiovascular or metabolic disorders. The sedentary criteria ensured those completing no more than one regular exercise session per week (>20 min) within the preceding 6 months. Those excluded were those with immunological irregularities, smokers (<2 yrs cessation); those suffering from recurrent or recent influenza illness (including flu shot recipients); those on cholesterol lowering, anti-inflammatory, or any other medication/condition reported to affect the inflammatory response (i.e. rheumatoid arthritis or periodontal disease). Prior to participant recruitment the study was approved by the Research in Human Ethics Committee of the University. All participants provided verbal and written consent prior to the commencement of testing procedures.

In a randomised cross-over design participants completed CYC and SSG conditions, each separated by 21 d to allow adequate recovery from an unaccustomed exercise session. Testing procedures commenced between standardised times (0600–0800 h), following an overnight fast (10–12 h). Physical activity and diet was controlled within each participant between conditions. Participants recorded physical activities 72 h prior and food/fluid ingestion 24 h prior to their first condition. Participants then replicated this diet and activity profile in preparation for the remaining condition. Diaries were inspected by the research team to ensure compliance with dietary and physical activity requirements. During each condition and 240 min after all testing sessions participants remained fasted and consumed water *ab libitum* (~500 mL).

At pre-intervention testing, stature (stadiometer: Custom CSU, Australia), body mass (HW 150 K, A&D, Japan), waist and hip girths (steel tape, EC P3 metric graduation, Australia) were obtained from all participants. Manual blood pressure was obtained with an aneroid sphygmomanometer and cuff (Welch-Allyn, Arden, USA) expressed as the mean of three measurements after being seated for 5-min. A supine whole body dual-energy X-ray absorptiometry (DXA) scan (XR800, Norland, Cooper Surgical Company, USA) was conducted with scanning resolution set at 6.5 mm × 13.0 mm, and scanning speed was set at 130 mm s^{-1}. Scans were analysed (Illuminatus DXA, ver.4.2.0, USA) for total body fat-free mass (TB-FFM) and total body fat-mass (TB-FM).[18]

Measurement of oxygen consumption (VO_2; Parvo Medics, True2400, East Sandy, Utah, USA) during a submaximal graded exercise test (GXT) was used in preference to maximal testing to minimise associated risks in sedentary, middle-aged men.[19] Prior to each session, the ventilometer was calibrated using a three-litre syringe, while gas analysers were calibrated for fractional gas concentration with a gravimetric gas mixture of known concentrations (CO_2, 4.1 ± 0.1%; O_2, 15.7 ± 0.2%), in accordance with the manufacturer's instructions. The GXT was performed on an electronically braked cycle ergometer (LODE Excalibur Sport, LODE BV, Groningen, The Netherlands), which started at 25W and increased by 25W every minute. Heart rate (Vantage NV, Polar, Finland) was continuously monitored, and participants exercised until attainment of 80% age-predicted (220-age) maximum heart rate (%HR_{max}).

The SSG condition involved modified football (non-contact rugby league) as this is the most popular football code in this geographical region.[20] Participants completed 40 min of six-a-side on a reduced-size pitch (width: 40 m; length: 60 m) to induce a mean target HR zone ~80–85%HR_{max}. To ensure participant randomisation between conditions, testing was conducted over 2 separate games (n = 4 in game 1 and n = 5 in game 2) with a standard team of volunteers who were not investigated in this study forming the remaining player numbers in each game. The session comprised of 4 × 10 min bouts, interspersed by 2 min passive recovery. Speed was recorded every second using a 1 Hz Global Positioning Satellite (GPS) device (SPIetite, GPSports, Australia). The GPS unit was worn in a customised harnesses between the scapulae to quantify distance and mean speed (m min^{-1}) of movement patterns during the session.[21] At the end of each 10 min period, HR and Rating of Perceived Exertion (RPE; Borg's 6–20 scale) were recorded, as well as a session-RPE 30 min post-exercise.[22]

The cycling condition was conducted on a Monark stationary cycle ergometer (Monark 828E, Varburg, Sweden) and comprised of 4 × 10 min continuous, steady-state bouts, interspersed by 2 min passive recovery. During the session, cadence was maintained at 60–65 rpm and individual resistance adjusted to maintain target HR zones (80–85%HR_{max}). At the end of each 10 min interval HR and RPE were recorded, including session-RPE 30 min following exercise. It is recognised the inherent difficulties of matching external training load or metabolic cost of two different exercise modes. Despite this limitation, in an attempt to match training load between conditions the respective exercise bouts were designed to elicit similar internal training loads. The intensity and duration of the cycling condition was designed to match the approximate