

The Effect of Acute Aerobic Exercise on Measures of Stress and Inflammation in Healthy Young Adults

Direct Original Research

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Abstract

Introduction: While the effects of long-term measures of inflammation and stress are well studied, less is known about the effects of an acute exercise challenge on exercise in young healthy individuals.

Methods: This was a randomized crossover design (mean age = 19.25, SD = 1.45) that measured biomarkers of stress (cortisol and salivary alpha amylase, sAA) and inflammation (IL-1 β , CRP) in an exercise and control condition. In the exercise condition, participants walked or ran on a treadmill at 75-85% of their maximum heart rate for 40 minutes. Under the control condition, participants stood for 40 minutes to control for orthostatic effects. Biomarkers were quantified from saliva collected before, 1 minute after, and 45 minutes after the exercise and control condition.

Results: The change in biomarkers from baseline values (+1 min and +45 min) between exercise and control conditions showed that compared to the control condition, the acute exercise bout significantly increased sAA CRP at +1min at +45 min and in IL-1 β +45 min. Cortisol levels significantly decreased at both time points in the control condition

Conclusions: Ultimately, the results of this study show how small and realistically achievable amounts of exercise can acutely strengthen the body's physiological responses to immune challenges.

Key Words: Aerobic exercise, cortisol, CRP, IL-1 β , sAA

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Introduction

Up to 27.5% of the population does not exercise sufficiently ¹. Following Covid-19, this has exacerbated for young, healthy adults. For example, a recent study showed that following Covid-19, 70% of male and female young adults aged 18-35 decreased their physical activity and only 30% met physical activity guidelines according to the International Physical Activity Questionnaires (IPAQ) ². This is concerning since aerobic exercise can improve overall health and specifically health of the immune system by increasing the recruitment and circulation of immune cells which can help the body combat infections ³. In general, the duration and intensity of the exercise and the physiological stress imposed by the exercise can influence how the immune system responds ⁴. While exercise of any intensity can have a beneficial effect on the immune system, very intense and prolonged exercise can increase an individual's risk of illness. However, regular (a few times per week) moderate-intensity exercise is associated with reduced inflammation ⁵. Given the ability of exercise to recruit various immune factors, even an acute bout offers the potential to confer immune activation and resiliency ⁶. Accordingly, the current

study sought to test the extent to which a single acute aerobic exercise bout in a group of young healthy adults altered markers of acute inflammation: CRP and IL-1 β and two associated measures of physiological stress: cortisol and salivary alpha amylase (sAA, a marker of norepinephrine activity ⁷). Moderate-intensity exercise was the preferred choice for this study as it circumvents the negative side effects of prolonged exercise while still being intensive enough to incite a physiological response in the body.

Scientific Methods

Participants

All procedures were carried out in accordance with a protocol reviewed and approved by an Institutional Review Board at Nova Southeastern University. Participant descriptives can be seen in Table 1. The study used a randomized, crossover design where each participant was tested under both conditions (exercise and control) one week apart. All study testing occurred between 11:00 am and 4:00 pm. Participants were tested at the same time each week to avoid possible circadian effects.

Table 1. Self-reported demographics

Gender	<u>N</u>	<u>%</u>	Race	<u>N</u>	<u>%</u>
Female	13	65%	Asian	1	5%
Male	7	35%	Black	4	20%
			White	14	70%
			Other	1	5%

Protocol

Following the consent process, body anthropometrics were measured via an InBody H20B (InBody USA, Cerritos CA). The InBody uses a Bioelectrical Impedance Analysis (BIA) to provide body composition components including weight, fat mass, muscle mass, and body fat percentage. Participants were then asked to fill out a demographics form. All participants then provided an initial (baseline) saliva sample via passive drool through a saliva collection aid (Salimetrics LLC, USA) into a standard 1.5 mL microcentrifuge tube. The participants then underwent either the exercise or control condition. Following this, they provided another saliva sample using the described passive drool method. They then provided a final saliva sample 45 minutes following the exercise or control condition.

In the exercise condition participants were first given a 5-minute warm up followed by a jog on a treadmill for 30 minutes, then a 5-minute cool down. The speed of the treadmill was adjusted to keep the participants at 75-85% of their maximum heart rate using the Karvonen formula (Target Heart Rate = (max HR - resting HR) $\times$ % Intensity) + resting HR. Max HR = 220-age. While running perceived exertion was also recorded. A heart rate monitor (Polar) was used to assess heart rate. Participants then had a 5-minute cool down. Under the control condition, participants stood for 40 minutes to control for non-specific orthostatic effects.

Saliva samples were run in duplicate and quantified using CRP and IL-1 β ELISA kits, cortisol EIA kits, and sAA enzyme reaction kits. All procedures were carried out according to the manufacturer's instructions (Salimetrics LLC, USA). For all assays, a commercial microplate washer was used (BioTek 50, BioTek Instruments, Inc., USA) and all plates used a BioTek ELx800 plate reader (BioTek Instruments, Inc., USA) to quantify the results. Final concentrations for each measure were generated by Gen5 software (BioTek Instruments, Inc., USA) using interpolation from the standard curve (CRP, IL-1 β , Cortisol) or absorbance at different reaction times (sAA). Data were produced in (pg/mLs for CRP and IL-1 β , μ g/dl for cortisol, and units (U) per mL for sAA).

Statistical Analysis

The data were analyzed using IBM SPSS statistics version 28. Paired sample t-tests were carried out to compare biomarker levels at baseline with levels in the post exercise/control (+1 minute) and post 45-minute (+45 minute) measurement. A paired samples t-test was also used to compare the resting heart rate (RHR) with maximum heart rate (MHR) during the exercise condition. The significance level was set to $p < 0.05$.

Results

Descriptive information for the participants can be seen in Table 2. The recorded heart rate at baseline and self-reported level of perceived exertion indicate that the participants were exercising at a moderate intensity.

Table 2. Descriptive Variable	Mean	SD
Weight (lbs)	147.03	32.73
Skeletal Muscle Mass	60.57	19.63
Body Fat Mass	38.44	15.24
Body Mass Index	25.34	6.08
Percent Body Fat	26.60	9.37
Control Resting Heart Rate	83.15	16.15
Exercise Resting Heart Rate	75.15	14.31
Exercise Max Heart Rate	182.55*	13.99
Exercise Perceived Exertion (1-10)	7.48	1.50

* indicates $t(19) = 35.91$, $p < 0.001$

Paired samples t tests (see Figure 1) of the biomarkers for the immune measures shows that compared to baseline only CRP significantly increased 1 min post-exercise $t(19) = 2.73$, $p = .007$. At 45 min post-exercise, both CRP $t(19) = 2.73$, $p = .007$ and IL-1 β $t(19) = 2.36$, $p = .02$ were significantly increased. Results for the measures of physiological stress showed that during the control condition, cortisol levels decreased significantly at both the 1 min $t(19) = 2.14$, $p = .02$ and 45 min $t(19) = 2.90$, $p = .005$ timepoints. sAA levels significantly increased at both the 1 min $t(19) = 4.48$, $p < .001$ and 45 min timepoints $t(19) = 2.01$, $p = .03$ in the exercise condition.

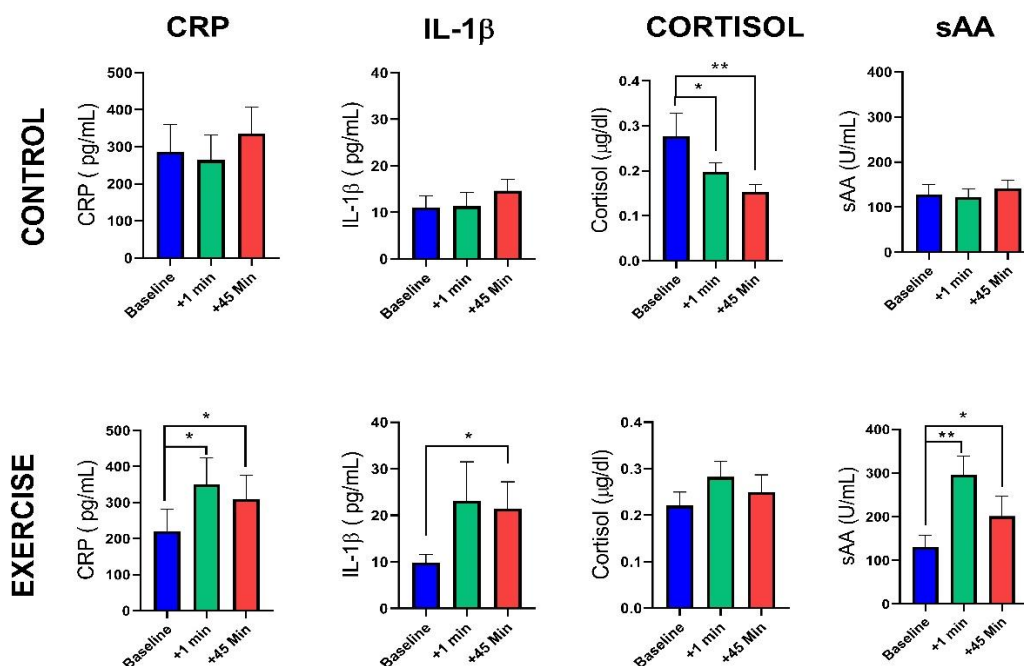


Figure 1. Biomarker data for the control and exercise conditions. Bars represent means + SEM, * indicates $p < .05$, and ** indicates $p < .01$.



Discussion

This study aimed to show if an acute moderate intensity aerobic exercise bout could significantly alter immune markers in otherwise young, healthy individuals. The significant increase in heart rate from baseline to maximal heart rate in the exercise condition, combined with the average self-reported exertion level, shows that under the exercise condition, participants reached the intended level of exertion.

The biomarker results of the study show that a single bout of acute aerobic exercise increases both CRP and IL-1 β cytokines. CRP levels rose faster than IL-1 β which makes sense since IL-1 β is upstream of CRP in the inflammatory cascade ⁸. Previous work has shown that acute increases in IL-1 β (from stress) can facilitate innate immune responses ⁹. This demonstrates that while contemporary research in exercise science focuses and encourages consistent moderate intensity exercise, a physiological response can be triggered with a single bout of exercise. The significant and sustained rise in sAA, as a marker of norepinephrine activity, is unsurprising and further supports that the participants were exercising at a moderate level. In agreement, a host of previous work shows that catecholamines are significantly increased as aerobic activity increases ¹⁰. Cortisol levels decreased in the control condition and did not increase in the exercise condition. As opposed to sympathetic activity, cortisol, as an end-product of the hypothalamic pituitary adrenal (HPA) axis, is more sensitive to psychological stress. Accordingly, we interpret these results to suggest that cortisol levels were elevated at baseline due to anticipatory arousal. This arousal decreased as participants adjusted to the testing environment in the control condition but were maintained in the exercise condition due to the sustained energy demands of exercise. Of note, this finding replicates a previous finding from our laboratory ¹¹.

Although the rise in biomarkers after exercise can be considered short-term, these initial rises can result in downstream increases in enhanced immunosurveillance ^{3,12,13}. In other words, the initial acute rise results in a cascade of events including increased recirculation of other immune-protective agents such as immunoglobulins, natural killer cells, cytokines, B cells and T cells ^{3,12,13}. The combined recirculation of these immune and stress components can enhance defense activity and metabolic health ^{3,12,13}.

Conclusions

The current study adds to the literature by showing that there is significant immune activation with acute aerobic exercise even when the individuals are young and healthy. In addition, the study population included both men and women, showing that these effects can likely be generalized to both sexes. An acute exercise bout of less than one hour is achievable for many people and holds the promise to serve as a non-pharmacological preventative measure to combat infection while still being short enough to easily fit in one's schedule.

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