Platelet Function and Coagulation During and Following Heat Stress

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Abstract

Purpose: The purpose of this study was to examine coagulation and platelet function in response to heat stress—induced passively and in conjunction with exercise. **Methods:** Eight healthy, college-aged males participated in two heat stress conditions; exercise-induced heat stress (EIHS) and passive heat stress (PHS). The EIHS condition consisted of 45 minutes of cycle ergometer exercise at a resistance of 2.0 - 2.5 kp while wearing encapsulating clothing. The PHS condition required subjects to sit in a tub at ~39.5˚C (±.5˚C) for 45 minutes, or until a core temperature had risen 1.5˚C from rest. Subject core temperature (Tc), thermal sensation (TS), and heart rate (HR) were measured at five minute intervals during both conditions. Pre, immediate-post, and 1-hour post condition blood draws were collected for each condition. The blood samples were analyzed for platelet function, fibrinogen, prothrombin (PT), activated partial thromboplastin time (aPTT) and complete blood count (CBC). A 2x3 (condition x time) repeated measures analysis of variance was run to determine significant effects for blood samples, whereas a 2x8 factor RMANOVA was used to determine significant differences for Tco, TS and HR. Significance was set at $p < 0.05$. **Results:** Tc increased significantly over time in both conditions, but there was no main condition effect. HR and TS increased significantly over time in both conditions, but subjects had significantly higher HR and TS during exercise. There was a significant main effect for time for platelet number, platelet function, fibrinogen, and aPTT. There was a significant condition effect for aPTT, WBC, and RBC, and a strong trend for platelets to be higher in the exercise condition ($p = 0.06$). **Conclusion:** The data from this study suggest heat stress, whether induced by exercise or passive heating causes changes in platelet function and coagulatory variables. Several factors had a more pronounced effect in the EIHS trial, suggesting that activation of the sympathetic nervous system may add to effects that are attributable to heat stress alone.

Introduction

Regular physical exercise is associated with a decreased risk of cardiovascular disease [1]. However, an acute bout of strenuous exercise, particularly in persons unaccustomed to physical activity, is associated with increased risk of a cardiac event. Platelet activation and enhanced coagulatory potential increase the likelihood of thrombus formation and therefore subsequent cardiovascular complications. Platelet hyperactivation and hypercoagulability have been reported following strenuous exercise and in heat stroke [2, 3, 4]. The effect of moderate heat stress, alone or in combination with exercise, on platelet function and coagulation, however, is not fully known.

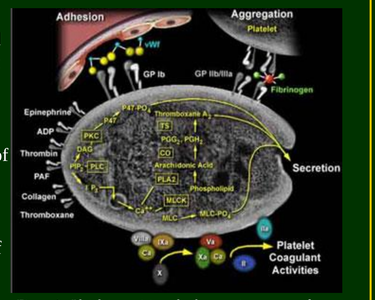


Figure 1. Platelet agonists and subsequent processes of adhesion, aggregation, secretion, and coagulation [5].

Purpose

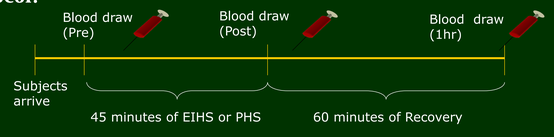
The purpose of this study, was to determine the effect of heat stress alone or heat stress with exercise on platelet function and coagulation. Heat stress was induced as either passive heat stress (PHS) or in conjunction with moderate exercise, exercise-induced heat stress (EIHS).

Methods

Subjects: 8, college aged, apparently healthy, fit males

Study Design: Repeated measures

Protocol:



EIHS – 45 min, 2 Kp, in encapsulating gear

PHS – 45 min, tub of warm water (38.9 - 40˚C)

Data Collection:

- Core temperature (Continuous internal monitoring; Mini-Mitter Respironics, Bend, OR)
- Anticubital blood samples collected in tubes containing 3.2% sodium citrate.
- Blood Parameters measured at all time points
  - ADP-induced platelet aggregability (PFA-100 Dade Behring; Deerfield, IL. USA).
  - Fibrinogen, PT, and PTT (Sysmex CA-1500, Sysmex America, Inc, Mundlein, IL USA).
  - P-selectin (ELISA, Biosource, Camarillo, CA).
  - Plasma cytokines (Linco, St. Charles, MO)

Statistical Analysis:

- 2 X 3 RMANOVA , main effect for time and condition.
- Paired t-tests for within condition differences and between condition differences.
- Chi Square was conducted on P-selectin data to determine a condition effect. (Critical Value set at 3.84)
- Statistical significance was set at $p < 0.05$.

Results

Table 1 Subject Descriptive Characteristics (n = 8)

Age (years)	20.4 ± 0.7
Height (cm)	175.1 ± 9.3
Weight (kg)	76.6 ± 12.6
Body Fat (%)	17.7 ± 6.5
VO_{2peak} (ml·kg^{-1}·min^{-1})	48.2 ± 4.3
2Kp % of VO_{2peak}	52.7 ± 8.9

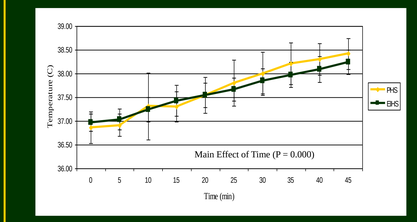


Figure 2a. Heart Rate

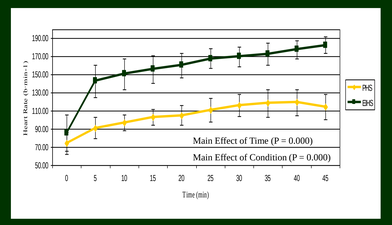


Figure 2b. Core Temperature

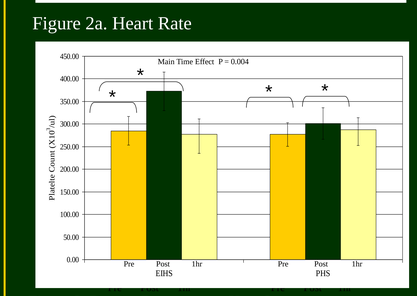
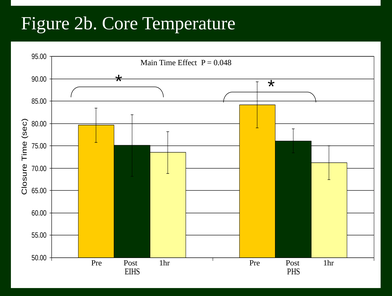


Figure 3. Platelet Responses to Heat Stress

a) Platelet Count



b) Platelet Function

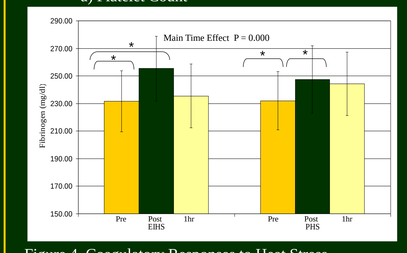
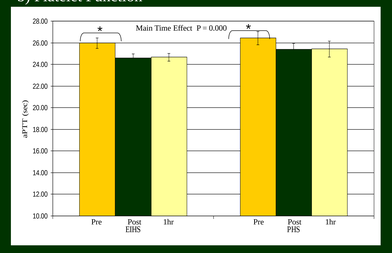


Figure 4. Coagulatory Responses to Heat Stress

a) Fibrinogen



b) aPTT

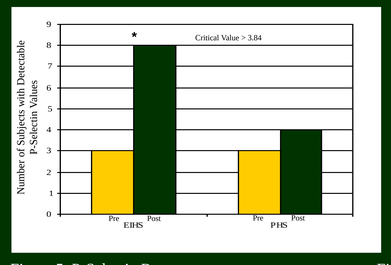


Figure 5. P-Selectin Response

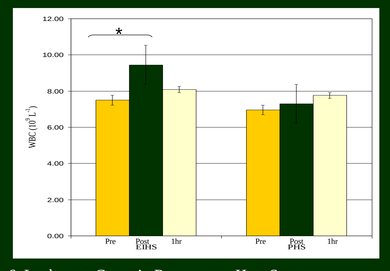


Figure 6. Leukocyte Count in Response to Heat Stress

Conclusion

Table 2. Comparison of PHS and EIHS

Variable	PHS	EIHS	Comparison
Platelet Count	↑	↑	PHS < EIHS
Platelet Function	↑	↑	No Difference
PTT	↓	↓	PHS < EIHS
Fibrinogen	↑	↑	No Difference
P-selectin	↔	↑	PHS < EIHS
WBC	↔	↑	PHS < EIHS
MCP-1	↔	↑	PHS < EIHS

Discussion

Platelets and coagulatory factors play an important role in endothelial repair, but can also induce the formation of an occlusive thrombus. Both severe heat stress (heat stroke) and strenuous exercise have been shown to elicit a pro-coagulatory response[6]. Changes in coagulatory potential during exercise have been attributed to activation of the sympathetic nervous system (resulting in an increase in circulating catecholamines)[7] and increased shear stress[8].

The results of the present study demonstrate that both moderate EIHS and PHS result in heightened coagulatory response. EIHS, however, induced a more exaggerated response in platelet count and PTT, and was shown to elicit P-selectin expression even though core temperature was elevated to the same extent in both conditions. Therefore, it appears that moderate heat stress alone increases coagulatory potential, but that the combination of exercise and heat stress increase coagulatory potential to a greater extent. This data suggests that exercise under conditions of heat stress may pose a greater hazard than exercise alone in individuals who are sedentary or have other cardiovascular risks factors.

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