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Beneficial effects of habitual resistance exercise training on coagulation and fibrinolytic responses

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ABSTRACT

Background: A sedentary lifestyle is a major risk factor for cardiovascular and thrombotic complications. While habitual endurance activity will reduce the risk of these adverse events, the influence of habitual resistance exercise is less clear. This study examined coagulation and fibrinolytic responses to an acute exhaustive resistance exercise test (AERET) in both resistance-trained (RT, min 2 yr, 5 men and 5 women) and untrained (UT, 5 men and 5 women) subjects.
Methods: The AERET consisted of six sets of 10 repetitions of squats at 80% of 1-repetition maximum. Venous blood was collected pre-exercise, immediate post exercise (IP), and +15, +60, and +120 minutes post exercise.
Results: Compared to UT, RT exhibited a lower capacity to form a clot as seen by activated partial Thromboplastin time (aPTT) integrated area under the curve over time (iAUC) levels, lower pre-exercise and 120 min post-exercise plasminogen activator inhibitor −1 (PAI-1) activity, and higher tissue plasminogen activator (tPA) activity immediately post-exercise. There were no significant differences between RT and UT for fibrinogen, prothrombin fragment 1 + 2 (PTF 1 + 2), and thrombin-antithrombin complexes (TAT).
Conclusion: These results suggest that habitual resistance exercise training may provide an enhanced fibrinolytic state.

Introduction

The Centers for Disease Control and the American College of Sports Medicine recommend that all individuals participate in at least 30 minutes of moderate-intensity physical activity on most days of the week. This includes endurance exercise 3–5 times a week and muscular strength training 2 times a week [1]. Muscular strength is known to be a vital part of an individual's ability to perform activities of daily living, such as lifting boxes, moving furniture, and carry groceries. Improved muscular strength allows individuals to live a more independent lifestyle. In addition, regular resistance training improves bone density [2], strengthens connective tissue, and increases lean body mass [3]. Physical inactivity increases the risk of thrombotic events and coronary artery disease [4–6] and numerous studies have documented the multitude of health and fitness benefits associated with habitual endurance activity and exercise (including improvements in cardiovascular and respiratory function [7], reduction in coronary risk [8,9], and decreased morbidity and mortality [10]). Despite the inclusion of resistance exercise in general recommendations; however, the benefits of resistance exercise alone on the coagulation and fibrinolytic systems are unclear.

Under normal conditions the blood coagulation and fibrinolytic system are in intricate balance, functioning to ensure proper formation and breakup of clots. Endurance exercise causes activation of the coagulation system while enhancing the fibrinolytic system [11,12]; however, these systems appear to respond differently to the mode, duration, and intensity of endurance exercise [13]. Recent reports suggest that moderate intensity endurance exercise activates blood fibrinolysis [14–16], but not coagulation, whereas very high intensity endurance exercise is associated with activation of both systems [17]. Many studies have only investigated coagulation and fibrinolytic function in chronically endurance trained subjects; however, there is limited information examining the effect of chronic resistance training

Abbreviations: AERET, Acute Exhaustive Resistance Exercise Test; RT, Resistance Trained; CRQ-10, CRQ-10 Rating of Perceived Exertion; UT, Untrained; aPTT, activated Partial Thromboplastin Time; PTF 1 + 2, Prothrombin Fragment 1 + 2; TAT, Thrombin-Antithrombin complex; PAI-1, Plasminogen Activator Inhibitor; tPA, tissue Plasminogen Activator; MI, Myocardial Infarction; 1-RM, 1-Repetition Maximum; iAUC, integrated area under the curve over time.

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on coagulation and fibrinolytic function, particularly during an acute resistance exercise bout. Despite the paucity of data in this area, the effects of endurance and resistance exercise training on blood clotting and fibrinolysis have been investigated to some degree [18–22]. Several studies have examined the effects of clot formation and breakdown during an acute endurance exercise bout in resistance trained individuals [17,23,24]. Fewer studies have looked at the effects of an acute resistance exercise on coagulation and fibrinolysis [22,25], although one study examined the impact of an acute resistance protocol on coagulation and fibrinolytic activity in untrained women [26]. Furthermore, a recent study examined untrained subjects who trained over the course of 4 weeks with bilateral knee extensions, a protocol that would be expected to elicit different metabolic and endocrine responses compared to multi-joint exercise [22]. At this time, we are not aware of any prior research that has examined chronically resistance-trained individuals (particularly as compared to untrained subjects).

Taken together, there is a lack of data on the influence of habitual resistance exercise training on the hemostatic system and its possible beneficial effects during periods of heavy physical exertion. Therefore, the purpose of this investigation was to determine the difference between untrained and resistance-trained individuals on coagulation parameters (activated Partial Thromboplastin Time (aPTT), prothrombin fragment I and II (PTF 1 + 2), and thrombin-antithrombin complex (TAT) and fibrinolytic parameters (Plasminogen Activator Inhibitor (PAI-1) and tissue Plasminogen Activator (tPA) across time in response to an acute bout of exhaustive resistance exercise. We postulate that habitual resistance exercise training will have a beneficial effect on the coagulation and fibrinolytic responses.

Materials and Methods

Study Overview

Each subject completed three laboratory visits. Subjects were thoroughly familiarized with the resistance exercise protocol prior to their first visit to eliminate any undue stress related to the novelty of the exercise. In addition, preparation for strength testing was also undertaken so subjects knew how to perform the exercise and approximate load determinations could be made. During the first visit, anthropometric data were obtained along with other descriptive data. The second visit involved obtaining each subject's fasting blood sample and determining the maximal amount of weight that could be lifted for 1-repetition maximum (1-RM). Approximately one week after the 1-RM determination, subjects performed an Acute Exhaustive Resistance Exercise Test (AERET) (described below) that has been used extensively in our laboratory [27]. During the AERET, blood was sampled before (pre) exercise, immediate post exercise (IP), and 15, 60, and 120 min into recovery for coagulation and fibrinolytic analyses (Fig. 1). Additionally, blood was taken from a control subject, who did not perform the AERET, at time points corresponding to (pre) exercise, IP, and 15, 60, and 120 used for the RT and UT groups. This blood was analyzed along side the RT and UT samples to rule out any methodological problems.

Subjects

Ten healthy resistance-trained (5 women, 5 men) and ten healthy untrained (5 women, 5 men) subjects volunteered for the investigation. Activity questionnaires were utilized to determine each subject's exercise status. Resistance trained subjects were defined as consistently performing a structured chronic resistance training program (defined as training 3 times a week) for at least 2 years prior to the start of the study, and not participating in cardiovascular activity more than 2 times a week. Non-resistance-trained subjects were defined as not having participated in a resistance exercise training program within the last six months, and not participating in cardiovascular activity more than 2 times a week.

Medical history and activity forms were also completed by each subject to ensure they met the inclusion/exclusion criteria, and were reviewed by a a physician to approve participation in the study. Subjects were excluded if a pre-existing medical condition put them at risk while performing the exercise protocol or would confound the results of this investigation. The medical exclusion criteria involved pre-existing heart conditions, respiratory conditions, blood pressure problems, musculoskeletal problems, or orthopedic injuries. Attention was given to exclude individuals with lower back problems included herniated inter-veterbral discs. People were also excluded from the study if they were using tobacco products, cholesterol lowering and blood pressure medications, anti-inflammatory mediation (aspirin or NSAIDS), anticoagulant medication (e.g. coumadin), flax or fish oil, Vitamin E supplement, or hormonal substances including testosterone, anabolic steroids, or growth hormones. Females reported where they were in there menstrual cycle and if they were taking oral contraceptives. The study was approved by the University of Connecticut Institutional Review Board for use of human subjects in research.

Experimental Controls

For both the 1-RM testing day and the AERET testing day, subjects arrived fasted (12 hours), having refrained from caffeine or alcohol

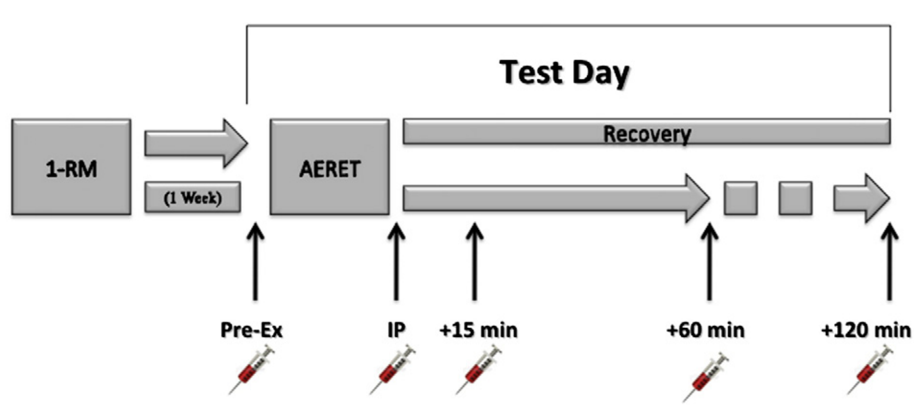

Fig. 1. Experimental Timeline. 1-RM, 1-repetition maximum; AERET, Acute Exhaustive Resistance Exercise Test (Six sets of ten repetitions at 80% of tested 1-RM). Blood was taken at pre-exercise, immediate post exercise (IP), 15 minutes post exercise, 1 hour and 2 hours post exercise.