Exercise and the Prothrombotic State

A Paradox of Cardiovascular Prevention or an Enhanced Prothrombotic State?

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Cardiovascular disease (CVD) is still a major cause of mortality and morbidity in the western world. The importance of a healthy lifestyle in reducing the risk of CVD cannot be over-emphasized, with many guidelines offering recommendations on lifestyle issues such as smoking, diet, alcohol, and physical activity. With regard to the latter, some official recommendations suggest that each individual should participate in a minimum of 30 minutes of “moderate intensity” activity at least five days a week.1 The latest Health Survey for England, however, highlights the vast discrepancies between targets and reality, demonstrating that up to three quarters of adults do far less than the recommended amount of physical activity.2 The concept that lifestyle and daily activities can be implicated in either increasing or decreasing the risk of development/progression of CVD has been highlighted by a variety of anecdotal and epidemiological evidence. In their original description of acute myocardial infarction (MI), Obraztsov and Strazhko3 were the first to report that “direct events” (such as exercise) often precipitated the disease. Many years later, Tofler et al4 demonstrated that in a population of patients who had experienced a MI, nearly half (48.5%) reported one or more potential trigger, with the most common reported being moderate/heavy physical activity (22.8%) followed by emotional upset (18.4%). In contrast, we found that only 21% of patients admitted with MI were engaged in physical activity at chest pain onset, with most patients being engaged in sedentary activities, including lying in bed (25%), sitting (19%), watching television (14%), and sleeping (6%); however, no ethnic differences in activity at chest pain onset were observed.5

In view of the possible links between acute stimulus and thrombotic event, investigators speculated that intense physical activity may trigger acute coronary thrombosis and coronary artery occlusion(s) in sedentary individuals or those with preexisting vascular disease by disrupting the delicate balance between the coagulation and fibrinolysis systems, as well as upregulating platelet activity. Subsequent to this, numerous studies examining the effect of acute exercise and physical training on hemostasis were undertaken in an attempt to confirm or refute this hypothesis.6,7 A recent systematic review7 suggested the plausibility of acute exercise inducing a prothrombotic state associated with abnormal fibrinolysis and platelet activation, but because of the large discrepancies in methodology between studies an element of caution was needed before drawing strong conclusions. With the large discrepancies in findings, investigators speculated that the hemostatic response to exercise may be influenced by numerous factors such as intensity of exercise, baseline fitness/sedentary status, and whether the exercise stimulus was acute or chronic.7,8 Indeed, Weiss et al9 demonstrated that the hemostatic response to acute exercise may be intensity-dependant, illustrating that moderate exercise (68%/VO2Max) yielded an enhancement of fibrinolysis without a concomitant increase in markers of blood coagulation, whereas very heavy exercise (83%/VO2Max) activated both systems simultaneously. Wang et al10 also demonstrated a similar trend in platelet reactivity, showing that in a sedentary population, platelet adhesiveness and aggregation could be upregulated by strenuous exercise, whereas moderate intensity (50% to 55% VO2Max) exercise had the potential to decrease the aforementioned below resting levels.

Hemodynamic factors may also influence changes in the prothrombotic state associated with acute exercise. Indeed, exercise is associated with increased flow in both arterial and venous circulation, shear-induced platelet aggregation (SIPA) may have an important role to play in the triggering of arterial thrombogenesis and vessel occlusion. When compared with a nonstenosed vessel, shear stress in stenosed arteries is accentuated (between 60 to 3300 dynes/cm²) because of the complex pattern of hydrodynamics, characterized by an initial increase in shear stress in the throat of the stenosed followed by a rapid decrease in the post stenosis circulation region.11 When the pathophysiological conditions of shear stress are recreated in a controlled in vitro environment using a rotational viscometer,12 an alternating monophasic flow pattern induced greater levels of SIPA than either low (10 dynes/cm²) or high flow (150 dynes/cm²) alone. Although the effects of acute exercise on in vitro SIPA have not been fully elucidated, Wang et al,10 in agreement with Tokue et al,13 demonstrated that intense exercise (>80% VO2Max) had the potential to increase SIPA, P-selectin, and GPIIb/IIIa expression and von Willebrand factor (vWF) binding to platelets. In this issue of Arteriosclerosis, Thrombosis, and Vascular Biology, Wang et al14 extend these observations further by

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verifying the effects of short-term strenuous exercise, as well as examining the effect of exercise training and deconditioning, on alternating shear-induced platelet aggregation (ASIPA). The authors used broadly similar methodology to that of Merton et al., and not only confirm previous findings that intense exercise (VO2Max) can increase ASIPA, but provided additional evidence to show that compared with a sedentary control group (exercise < once per week, < 20 minutes), individuals on an 8-week training program (60% VO2Max, 30 minutes a day, 5 to 7 days) exhibit reduced ASIPA, vWF binding and P-selectin expression both at rest and during intense exercise. Because the current literature on the effects of regular exercise on coagulation, fibrinolysis, and platelet reactivity are highly variable,7 this recent study by Wang et al.14 provides new insights into the possible protective effects of regular exercise in the downregulation of platelet activity. However, the downregulation of platelet activity after 8 weeks of regular physical activity could easily revert back to a pretrained state if individuals returned to a sedentary lifestyle. This study, as with many of its kind, is also limited by the fact that it has been performed in male individuals who are young and healthy, and therefore further work would be required to confirm the present findings in females (and the corrections for the hormonal cycle it necessitates) and in patients with existing cardiovascular disease. Indeed, if studies were performed in patients with a preexisting (abnormal) hypercoagulable state, such as atrial fibrillation, the effects of acute exercise on indices of the prothrombotic state may be unimpressive.15 In addition, it is quite difficult to fully correlate the in vitro or ex vivo findings to the true in vivo biological activities as no experimental method can fully and precisely reproduce the biological scenario, nor can any statistical test or method fully adjust for all biological processes. As psycho-social stress also represents an independent risk factor for developing CVD, potentially through altered coagulation and/or platelet hyperactivity,16,17 future studies in this area examining the effect of acute mental stress in combination with varying degrees of physical exercise status (sedentary/moderate/high intensity, etc) would perhaps be of value.

From the available literature, it would appear that on one hand, regular habitual exercise can reduce the risk of CVD by improving an individual’s hemostatic profile both at rest and during exertion, but on the other hand, vigorous exercise may provoke sudden cardiac death in individuals with preexisting vascular disease.18 Indeed, this “paradox” of vigorous versus regular habitual exercise raises the possibility that a “two-edged sword” of exercise may exist in relation to activation of the hemostatic system and enhanced thrombogenesis.8 The findings by Wang et al.14 link well with the current recommendations with regards to regular physical activity. Their training program, which closely mirrors the current recommendations, provides further evidence to support the health promotion drive to get the large number of sedentary individuals into regular physical activity, potentially reducing the large number of deaths related to CVD.

References

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