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Trained men show lower cortisol, heart rate and psychological responses to psychosocial stress compared with untrained men

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Summary
Physical activity has proven benefits for physical and psychological well-being and is associated with reduced responsiveness to physical stress. However, it is not clear to what extent physical activity also modulates the responsiveness to psychosocial stress. The purpose of this study was to evaluate whether the reduced responsiveness to physical stressors that has been observed in trained men can be generalized to the modulation of physiological and psychological responses to a psychosocial stressor. Twenty-two trained men (elite sportsmen) and 22 healthy untrained men were exposed to a standardized psychosocial laboratory stressor (Trier Social Stress Test). Adrenocortical (salivary free cortisol levels), autonomic (heart rate), and psychological responses (mood, calmness, anxiety) were repeatedly measured before and after stress exposure. In response to the stressor, cortisol levels and heart rate were significantly increased in both groups, without any baseline differences between groups. However, trained men exhibited significantly lower cortisol and heart rate responses to the stressor compared with untrained men. In addition, trained men showed significantly higher calmness and better mood, and a trend toward lower state anxiety during the stress protocol. On the whole, elite sportsmen showed reduced reactivity to the psychosocial stressor, characterized by lower

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adrenocortical, autonomic, and psychological stress responses. These results suggest that physical activity may provide a protective effect against stress-related disorders.

1. Introduction

There is substantial evidence indicating that physical activity has beneficial effects on physical and mental health and that it is protective against the detrimental consequences of chronic stress and stress-related diseases, such as cardiovascular disorders (Perkins et al., 1986; Steptoe et al., 1993; Talbot et al., 2002; Ketelhut et al., 2004; Barlow et al., 2006) or depression (Ross and Hayes, 1988; Blumenthal et al., 1999; Babyak et al., 2000; Motl et al., 2004; Nabkasorn et al., 2006). In addition, several studies demonstrated that regular physical activity contributes to a reduced responsiveness to acute physical stressors (Luger et al., 1987; Deuster et al., 1989; Petruzzello et al., 1997) or reported reduced susceptibility to the adverse influences of life stressors in physically active people (Tucker et al., 1986; Steptoe et al., 1989; Throne et al., 2000). However, the extent to which physical activity may reduce the responsiveness to *psychosocial* stressors, thereby contributing to the prevention of stress-related disorders with major public health significance, is still a much-contested issue (McEwen, 1998).

The physiological reactivity to both physical and psychological stressors leads to increases in cardiovascular and neuroendocrine measures, reflecting autonomic nervous system (ANS) and hypothalamic–pituitary–adrenal (HPA) axis responses (Luger et al., 1987; Deuster et al., 1989; Kirschbaum et al., 1993; Duclos et al., 1997; Singh et al., 1999; Dickerson and Kemeny, 2004). Following chronic stress, alterations in these systems have been linked to the development of stress-related disorders (Steptoe, 1991; McEwen, 1998). Interestingly, physical activity has been found to reduce ANS and HPA reactivity to physical stressors in trained subjects (Luger et al., 1987; Deuster et al., 1989). A possible adaptation of stress-responsive systems due to exercise may influence stress responses not only to physical stressors but also to mental stressors (Claytor, 1991; Cox, 1991; Sothmann et al., 1991, 1996).

Based on this background, physical activity could be regarded as a general protective factor against different kinds of stressors. However, both cross-sectional and longitudinal studies using psychosocial stressors have reported inconsistent findings (de Geus and van Doornen, 1993), with the vast majority of these studies focusing on cardiovascular changes. Whereas some studies reported blunted cardiovascular responses or a more rapid recovery in trained men (Sinyor et al., 1983, 1986; Holmes and Roth, 1985; Crews and Landers, 1987; Boutcher and Landers, 1988; Steptoe et al., 1990; Moya-Albiol et al., 2001; Spalding et al., 2004), others were unable to confirm such effects, or even reported higher reactivity (de Geus and van Doornen, 1993; Jackson and Dishman, 2006). With respect to the sympathetic-adrenal-medullary reactivity, some studies found no effect of fitness on norepinephrine and epinephrine levels in plasma or urine (Brooke and Long, 1987; Claytor et al., 1988; de Geus et al., 1993), while others reported higher norepinephrine levels in plasma in trained subjects early on in the stress period (Sinyor et al., 1983). In contrast, some studies found lower levels of fitness to be associated with an augmented norepinephrine response (Sothmann et al., 1991; Moyna et al., 1999). Notably, studies on HPA axis reactivity to psychological stressors did not show significant effects of physical fitness on cortisol levels (Sinyor et al., 1983; Moyna et al., 1999). Regarding psychological measures, Sinyor et al. (1983) found aerobically fit subjects to exhibit lower state anxiety following a psychological stressor. It appears that being physically active may differentially influence an individual's reactivity to psychosocial stress depending on the kind and intensity of physical activity, the level of physical fitness, the age and gender of the subjects, the method of measurement, the time of day of stress induction, and the type of stressor. It might be the case that these previous studies (Sinyor et al., 1983; Moyna et al., 1999) used stressors with less social impact, which might have prevented different responses in physically trained versus untrained subjects. In contrast, studies using a stressor that combines mental arithmetic and a speech test induced a strong endocrine response (Biondi and Picardi, 1999), but have barely been used to investigate the stress response of trained men. We used the standardized Trier Social Stress Test (TSST) (Kirschbaum et al., 1993), which enables a naturalistic exposure to a socio-evaluative stressful situation, with two- to three-fold increases in HPA axis and cardiovascular responses (Dickerson and Kemeny, 2004).

In the present study, we set out to determine possible protective effects of a high level of physical activity on parallel measures of adrenocortical (salivary cortisol), autonomic (heart rate), and affective (mood, calmness, anxiety) responses to a standardized psychosocial stressor. To compare stress responses between two groups that clearly differ in their level of physical activity, we included well-trained (elite sportsmen) and untrained men in this study.

2. Methods

2.1. Participants

Twenty-two elite sportsmen (mean $\pm$ SD; age, 21.50 $\pm$ 2.35 years) and 22 untrained men (21.84 $\pm$ 2.24 years) were recruited by the Swiss Federal Office of Sports and by advertisements at the local universities in Zürich. Elite sportsmen were primarily recruited from endurance-trained sports and had a Swiss Olympic Card and/or were members of the Swiss national teams. Subjects who exercised for less than 2 h per week were classified as ''untrained''. Trained and untrained men did not significantly differ in terms of age, BMI, psychological symptoms, and perceived stress (all