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Does the level of physical exercise affect physiological and psychological responses to psychosocial stress in women?

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ABSTRACT

Objectives: To test the Cross-Stressor Adaptation hypothesis for females by examining whether physically exercising young women show reduced physiological and psychological stress responses to a psychosocial stressor.
Design: Forty-seven healthy young women with different levels of physical exercise (17 not or rarely exercising, 15 moderately exercising, 15 vigorously exercising) underwent the Trier Social Stress Test for Groups (TSST-G); physiological and psychological stress responses during and after stress induction were compared.
Method: ANOVAs with repeated measures were used to compare stress reactivity and recovery between the three exercise groups. Heart rate and salivary free cortisol were used as indicators of physiological stress response, state anxiety, mood, and calmness as indicators of psychological stress response. For physiological stress reactivity, the areas under the curve with respect to the ground (AUC_G) were compared.
Results: In all three exercise groups, experimentally induced stress led to a significant rise in heart rate, cortisol, and state anxiety; mood and calmness significantly decreased. As hypothesized, the pattern of the physiological stress response differed for the three exercise groups, with lowered reactivity in the more active groups. However, the psychological stress response partly went in the opposite direction: Exercising participants reported a higher mood decrease, suggesting a dissociation of the physiological and psychological stress responses.
Conclusions: The findings suggest that the Cross-Stressor Adaptation hypothesis is also valid for young women; however, only with regard to physiological stress response. The unexpected findings for psychological stress response need to be further explored in experimental studies.

Introduction

There is profound evidence suggesting that regular physical exercise is beneficial not only for physical health but also for mental health (Raglin & Wilson, 2012). In particular, physical exercise has been found to exert antidepressant and anxiolytic effects that are clinically relevant (Rethorst, Wipfli, & Landers, 2009). However, although stress is one of the major threats for physical and mental health (Chrousos, 2009), surprisingly little is known about the stress-regulatory role of physical exercise (Fuchs & Klaperski, 2012). In the literature, one of the most discussed assumptions on how physical exercise might influence the stress-coping system is the so-called "stress-buffer hypothesis of physical exercise." Physical exercise is thought to act as a moderator of the stress-health relationship by reducing the detrimental effects of chronic stress (e.g., at the workplace) on physical and mental health, or in other words by "buffering" the negative health effects of stress (Gerber, Kellmann, Hartmann, & Pühse, 2010; Tsatsoulis & Fountoulakis, 2006). However, only a small majority of studies conducted on this topic found full or at least partial support for the stress-buffering hypothesis (Gerber & Pühse, 2009; Klaperski, Seelig, & Fuchs, 2012).

Several authors cite the "Cross-Stressor Adaptation hypothesis" (CSA hypothesis) as a possible mechanism for the stress-buffering effect of physical exercise (Hamer, Taylor, & Steptoe, 2006; Sothmann, 2006). The CSA hypothesis states that regular exercise leads to biological adaptations which contribute to a reduced

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physiological reaction of the sympathetic nervous system (SNS) and the hypothalamic–pituitary–adrenal (HPA) axis to stressors *in general* (Hamer et al., 2006; Tsatsoulis & Fountoulakis, 2006). A reduction in physiological stress reaction is reflected by (a) a lower stress *reactivity*, i.e. the deviation from the physiological baseline is smaller, and (b) a faster stress *recovery*, i.e. less time is needed to return to the physiological baseline (Forcier et al., 2006). Chronic hyper-elevated activations and slow recovery of the stress-systems have a negative impact on health (Carroll, Lovallo, & Phillips, 2009; Chrousos, 2009), and a high reaction to laboratory stressors is associated with a higher risk of stress-related diseases (Chida & Steptoe, 2010; Ellenbogen, Hodgins, Walker, Couture, & Adam, 2006). A confirmation of the CSA hypothesis would emphasize the importance of physical exercise for health, as it would result in a health-protective lower physiological reactivity and faster physiological recovery from stressful events (Kemeny, 2003; Tsatsoulis & Fountoulakis, 2006). So far it is unclear whether an exercise-induced attenuated physiological stress reaction is paralleled by a lowered psychological stress reaction (e.g., reduced anxiety).

There are conflicting empirical findings regarding the effects of physical exercise (and fitness) on reactivity and recovery in psychosocial stress situations (Dishman & Jackson, 2000). First of all, several cross-sectional studies with non-clinical samples demonstrated that regularly exercising or fit persons show reduced physiological stress reactions and partly reduced psychological stress reactions when confronted with experimentally induced psychosocial stressors. Rimmele et al. (2007), for example, found a lower heart rate reactivity and a reduced salivary free cortisol response along with a smaller mood decline and a tendency for a greater increase in anxiety in elite sportsmen compared to untrained men in response to the Trier Social Stress Test (TSST; Kirschbaum, Pirke, & Hellhammer, 1993), a standardized stress-induction protocol. More recently, Rimmele et al. (2009) replicated and extended the results of this study and showed that amateur sportsmen also had a significantly lower heart rate *reactivity* than untrained men, but that both groups had a significantly greater cortisol response than elite sportsmen; however, no *recovery* differences were found between the three groups. Furthermore, throughout the study the highest anxiety levels were observed in untrained men and the lowest in elite sportsmen. However, no significant time by group interactions emerged (Rimmele et al., 2009). Conversely, other cross-sectional studies did not find differences in stress response between trained and untrained men (e.g., Moyna et al., 1999).

More profound support of the CSA hypothesis stems from randomized controlled training studies (RCT) with non-clinical samples. Spalding, Lyon, Steel, and Hatfield (2004), for instance, found a reduced cardiovascular stress reactivity and better recovery from a mental arithmetic stressor with auditory distraction in males and females who had completed a six-week aerobic exercise program, compared to a weight training and a non-intervention group. However, other RCT studies showed no such or rather ambiguous effects (e.g., de Geus, van Doornen, & Orlebeke, 1993). Meta-analyses focusing on cardiovascular stress responses to psychosocial stress (Forcier et al., 2006; Hocking Schuler & O'Brien, 1997; Jackson & Dishman, 2006) found physically active persons to possess a better cardiovascular *recovery* after stress exposure. However, while Forcier et al. (2006) state that physical exercise is also linked to a lower cardiovascular *reactivity*, the meta-analysis from Jackson and Dishman (2006) did not support this assumption. In the only meta-analysis to also analyze endocrine stress response, van Doornen and de Geus (1993) concluded that there is no link between physical fitness and hormonal components of the stress response. Sothmann (2006) summarized the state of research in this area by reasoning that "based on the neuroendocrine data one cannot substantively argue for an impact of exercise training in augmenting or reducing stress reactivity in psychosocial settings" (p. 156). The author calls for more sophisticated experimental designs and more research with currently underrepresented female samples.

Two of the rare studies with women are from Summers, Lustyk, Heitkemper, and Jarrett (1999) and Traustadóttir, Bosch, and Matt (2005). Summers et al. (1999) did not find any differences between fit and unfit women in the catecholamine response (pre and post urine sample) to a mild psychological stressor (Stroop Color–Word Test) in the follicular phase. In contrast, Traustadóttir et al. (2005) showed that higher physical fitness in post-menopausal women was linked to a lower endocrine stress response (plasma cortisol). However, findings focusing on different stress responses from different age groups and genders must be compared carefully, as age and gender strongly affect physiological and psychological stress response (see Jackson & Dishman, 2006; Kudielka, Hellhammer, & Wüst, 2009). Kelly, Tyrka, Anderson, Price, and Carpenter (2008), for example, found women to report greater psychological stress than men on the TSST, although both groups showed similar physiological stress responses. These findings also illustrate that caution must be exercised when transferring conclusions for physiological stress response to psychological response or vice versa. According to Campbell and Ehlert's (2012) review of the empirical evidence, physiological and psychological stress responses are often not, as usually assumed, interrelated; rather, they found "dissociations" of the stress responses to be a common phenomenon in studies applying the TSST to examine stress responses.

In sum, there is some evidence in support of the CSA hypothesis that regular exercise results in a more beneficial cardiovascular and endocrine stress response. However, less is known about exercise-induced changes in psychological stress responses and about how these psychological reactions relate to physiological reactions. We identify two main limitations of the current research on the CSA hypothesis: (1) Most studies were conducted with men, and thus more research is needed with female samples. (2) The majority of previous studies used non-standardized and non-validated methods of stress induction, hampering comparability and raising the question whether stressors were appropriate (ecologically valid) for detecting differences in stress responses. Hence, we set out to test the CSA hypothesis in a sample of young women with different levels of physical exercise by comparing their physiological (heart rate, salivary free cortisol) and psychological (anxiety, calmness, mood) stress responses to a standardized psychosocial laboratory stressor in a group format (TSST for Groups; von Dawans, Kirschbaum, & Heinrichs, 2011).

Methods

Participants

Fifty women were recruited by advertisements and personal address at the University of Freiburg, in local sporting teams, and at local sports clubs in Freiburg, Germany. The participants were between 18 and 28 years of age, reported that they engaged regularly in at least 3 h of exercise[1] a week or did not exercise regularly at all, did not take any hormonal contraceptives (Kirschbaum, Kudielka, Gaab, Schommer, & Hellhammer, 1999), and did not smoke more than five cigarettes per day. Further exclusion criteria in the study were symptoms of psychopathology, reported medical

[1] The term "exercise" covers all forms of sporting exercise but does not cover daily physical activity, e.g., housework.